Merlin LT

Vessel-based LIDAR system

user manual

Contents

1 Customer information

1.1 Dear customer

The Merlin LT system is designed to be easy to operate. However, we would ask you to take the time to read these operating instructions carefully before using the system, and to keep the manual with the instrument at all times.

For any feedback or comments, or if there are questions about the Merlin LT which are beyond the scope of this manual, contact the product support department at Carlson, or your local Carlson representative.

Alternatively, for information on your local Carlson-approved service centre, visit our website: www.carlsonsw.com.

To ensure best service, please make a note of your Merlin LT's serial number. This can be found on the instrument.

1.2 User manual

This Merlin LT manual has a Carlson part number of H-0218-8000.

This version is H-0218-8000-01-A, released in November 2019.

It is important that you read this manual carefully before using the equipment. The manual comprises three main sections:

1. The Merlin LT vessel-based lidar system hardware, describing the Merlin LT system and all accessories supplied with a standard system.

2. The installation and use of the Merlin LT system on a vessel. Be sure to fully understand this section before starting an installation.

3. The Merlin diagnostic software, showing how the software enables basic configuration and testing of the Merlin LT.

This manual does not cover the calibration of the Merlin LT in hydrographic acquisition software packages. These are detailed in separate quick-start guides: QINSy (Carlson part no. H-9931-9506), HYPACK (H-9931-9505), and PDS (H-9931-9512).

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1.3 General safety

CAUTION: Before unpacking and installing the Merlin LT system, read the safety instructions throughout this manual carefully and ensure that they are followed at all times by all operators. Failure to do so could adversely affect the performance of the Merlin LT system and/or lead to personal injury. Operators must be trained in the use and application of the Merlin LT system and accompanying accessories before being allowed to operate the system.

1.3.1 Operation and maintenance

Following the simple maintenance procedures below will prolong the operational life and continued high

performance of the system. The user should determine the frequency of inspection and maintenance actions according to the conditions of use.

- The product is to be used only with the appropriate Carlson-supplied cabling.

- Installation of the Merlin LT system must be performed only by trained personnel.

- Changing the Merlin LT port and IP addresses must be carried out using only the Merlin diagnostic tool software by appropriately trained personnel.

- Disconnect power before performing any maintenance operations.

- Maintenance is restricted to procedures described in section 8.

- Beware of unexpected mechanical movement. The user must remain outside the full working envelope of the Merlin LT system whilst in operation.

- It is the machine supplier's responsibility to ensure that the user is made aware of any hazards involved in operation, including those mentioned in Carlson product documentation.

- The Merlin LT system must be transported in Carlson-supplied packaging.

- This equipment is not suitable for use in a potentially explosive atmosphere.

1.3.2 Precautions

- There are no user-serviceable parts inside the unit. Do not remove any panel. Do not attempt to service parts inside the unit. If servicing is required please contact Carlson.

- Unauthorised removal of any panel may expose live connection points and non eye-safe laser radiation.

- Avoid directing the laser apertures towards the sun or other high-powered, infrared light sources.

- Avoid mechanical shocks

- The laser is driven by a rotating motor. If the motor is rotated by hand or prevented from moving by an obstruction, the motor will not be damaged. It is advisable, however, to minimise any manual movement of the laser and to keep the instrument away from potential obstructions so the motor may turn freely.

- Users should not manually or otherwise obstruct the operation of the motor or allow clothing to come into contact with the device, to avoid entrapment in the unit.

2 Introduction

2.1 System overview

Merlin LT is a development from the Merlin, Carlson's first, time-tagged, vessel-based lidar system. The Merlin LT can be operated from any vessel platform and is designed specifically for use in extreme and changeable marine environments. Its plug-and-play design offers quick and simple deployment, as well as easy integration into existing vessel infrastructure, such as an inertial measurement unit (IMU), global navigation satellite system (GNSS) receivers, and industry-standard hydrographic acquisition software packages.

The Merlin LT is designed to be lighter-weight, and of a smaller footprint, than the standard Merlin system, while the capabilities of the laser remain the same.

The instrument employs the 'time-of-flight' laser measurement technique to measure ranges to above-water topography without the need to place reflectors at the target. This allows accurate measurements to be made of inaccessible points, such as cliff faces and rock groynes, from the relative safety of the survey vessel. With the Merlin LT integrated into the vessel's navigation system and the sensors all calibrated with respect to the IMU, the laser data can be collected at the same time as underwater data is collected.

Merlin LT is supported by drivers in all the main hydrographic survey / navigation software packages, including QINSy, HYPACK, EIVA and PDS. This support provides flexibility to end users involved with a wide variety of clients, applications and global locations.

Merlin LT observes 36,000 points per second, with a 360° field of view.

The Merlin diagnostic tool software is supplied with Merlin LT. This can be used to program IP addresses, change port numbers, fault-find, and carry out diagnostic checks on the system.

2.2 Applications

This innovative instrument is suitable for a large number of surveying and measuring functions, including:

- Infrastructure planning

- Offshore construction

- Coastal erosion monitoring

- Port and harbour surveys

- Navigation chart updates

- Flood-risk management

- Canals and inland waterways

- Inspection surveys

- Bridge condition surveys

- Terrestrial mobile mapping

3 Equipment description

The sections below describe each individual hardware element of a standard Merlin LT vessel-based lidar system.

3.1 Merlin LT

The Merlin LT unit incorporates a rotating laser range finder which is housed with a motor and encoder in a weather-proof pod, held between two 'A-frame' pillars that sit on a base plate.

3.1.1 Laser

The laser contains the optical and electronic components that allow distance measurements to be recorded to reflectorless targets up to 250 m from the instrument.

Figure 1 Rotating laser module

The laser uses a 'time-of-flight' method to measure ranges to remote targets.

The two lenses visible within the laser module are the transmitting and receiving optics. It is through these optics that the infrared measuring laser is fired, and its reflected light is received back into the instrument.

The laser measures 36,000 ranges each second, to an accuracy of +/-1 cm.

The laser ranges up to a limit of 250 m to 90% reflective material (e.g., Kodak white card). However, the maximum achievable range at any given time or location will depend on a number of factors. In some circumstances these may prevent any readings from being taken:

- dark, light-absorbent surfaces such as coal;

- atmospheric conditions such as dust, fog, heavy rain and snow;

- wet, slick, shiny or very smooth surfaces;

- an acute angle between the laser and the surface.

The minimum, calibrated range of the laser is 0.5 m. At shorter distances, readings may still be recorded, but their accuracy may be diminished.

An internal motor physically rotates the laser housing at up to 20 times per second.

An encoder measures the rotational angle of the laser to an accuracy of 0.01°.

3.1.2 A-frame and base plate

The pod can rotate vertically around the vertical pivot at the top of the A-Frame. The fixed angles are 90° (horizontal), 45° and 0° (vertically up).

Figure 2 Merlin positioned vertically at 90°, 45° and 0°

Figure 3 Merlin A-frame and base plate

Changing the vertical inclination of the Merlin can help to produce more useful data, depending on the nature of the scene being scanned and on the specific project requirements.

Leave the pod horizontal – at 90° – to generate vertical sections of points as the laser rotates.

Incline the laser to 45°, and the section of scanned points is also inclined. This can help to pick out vertical features such as lamp posts, pillars and building edges.

At 0° The Merlin LT generates horizontal sections of points. This orientation can be used for proximity detection and to assist dynamic positioning.

If the unit is repositioned with a different vertical angle, new lever arm values must be used. The pitch calibration values must also be changed in your navigation package.

Use the four holes in the base plate to secure the Merlin LT directly to a mounting point on a vessel. Alternatively, use the base plate to secure the Merlin LT to the mounting plate (see section 3.6.1).

A central point on the base plate marks a measurement datum point which you can use when surveying the lever arm offset.

3.1.3 Connectors

There are four connectors on the Merlin LT unit, at the rear of the pod.
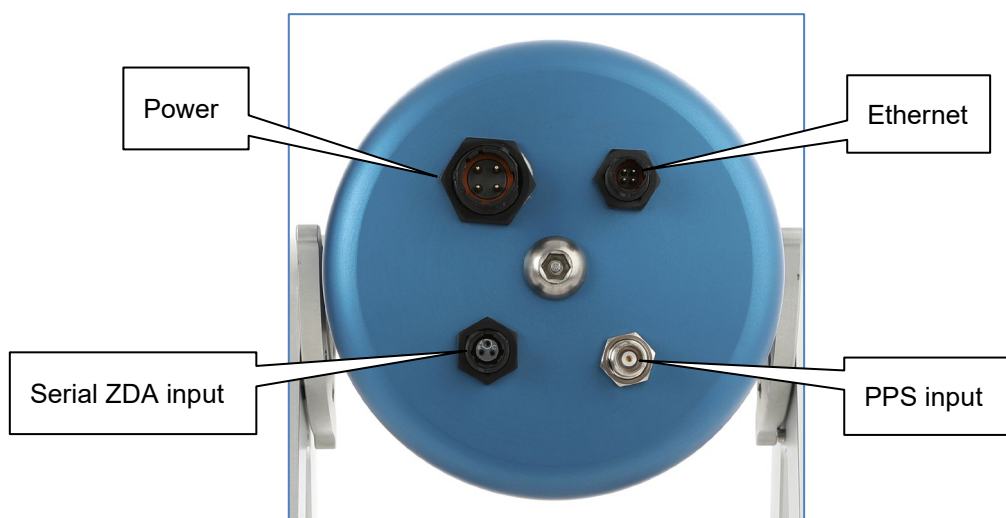
Figure 4 Merlin LT connectors

Each connector is uniquely matched to one of the supplied cables described in section 3.2.

When the cables are correctly and securely attached to the Merlin LT, the connections are watertight.

The connectors are supplied with protective caps which should be placed on the connector when the system is not in use and cable are disconnected.

3.2 Cables

All supplied cables must be connected and correctly interfaced for the Merlin LT to run fully optimised operations.

When secured to the back of the Merlin LT, each connection is protected against the environment.

Figure 5 All cables connected to the Merlin LT

3.2.1 Ethernet cable

Figure 6 Ethernet cable

The Ethernet cable provides communication between the Merlin LT and the vessel's main PC running navigation software.

The Cat 6 Ethernet cable attaches to the back of the Merlin LT with a four-pin female Souriau connector. The standard RJ45 connector connects to the PC.

3.2.2 PPS cable

Figure 7 PPS cable

The PPS cable delivers a timing pulse to the Merlin LT.

The PPS cable is a coaxial RF cable. A threaded TNC connector attaches to the connector on the back of the Merlin LT. A bayonet BNC connector is on the other end. This connects to the source of the PPS output.

3.2.3 Serial cable

Figure 8 Serial cable

The serial cable delivers ZDA timing messages from an external timing source to the Merlin LT unit.

The serial cable attaches to the back of the Merlin LT via a three-pin male Souriau connector. The 9-way D-type connector on the other end connects to the source of the ZDA output.

See section 6.1.3 for details of the serial cable pin-outs.

3.2.4 Power

Figure 9 Power cable

The power cable attaches to the back of the Merlin LT via a four-pin female Souriau connector. On the other end are ring-crimp connectors which connect to a dc power supply of voltage range 12 V dc.

See section 5 for details of electrical connections.

3.3 Transit case

The Merlin LT system is supplied in a rugged transit case designed to transport the unit and all accessories.

Figure 10 Merlin LT system in transit case

The case protects the equipment from minor shocks and from the environment. Use the transit case at all times when transporting and storing the Merlin LT system.

Take care to clean and dry the Merlin LT unit and accessories before packing them into the case.

3.4 USB drive

The Merlin LT USB stick contains the Merlin diagnostic tool software and this Merlin LT installation and operation manual. Copy and install all files onto the vessel's PC.

3.5 Merlin diagnostic tool software

The Merlin diagnostic tool software is a simple application which allows the set-up and configuration of the Merlin LT system. It is loaded on the USB stick that is supplied in the Merlin LT transit case. Plug the USB stick into the your PC and double-click on the installer application to launch it. Follow the on-screen installation instructions.

A shortcut of this application will be created on the desktop for ease of use.

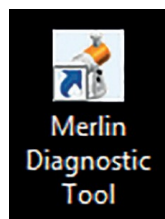The Merlin diagnostic tool software is compatible with Microsoft Windows 7, 8 and 10.

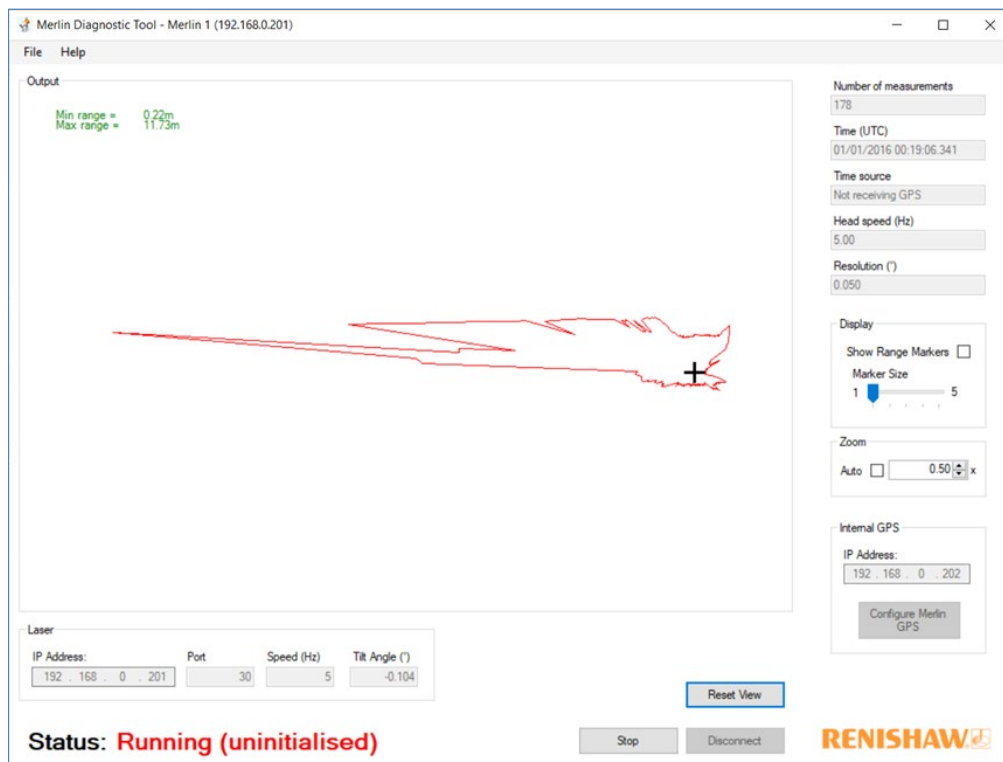*Figure 11 Merlin diagnostic tool desktop shortcut*

Figure 12 Merlin diagnostic tool software

For details of the Merlin diagnostic tool operation, see section 7.

3.6 Optional accessories

3.6.1 Mounting plate

The Merlin LT can be directly secured to a vessel using the holes in the base plate. Alternatively, the mounting plate is supplied to offer more flexibility during the installation process.
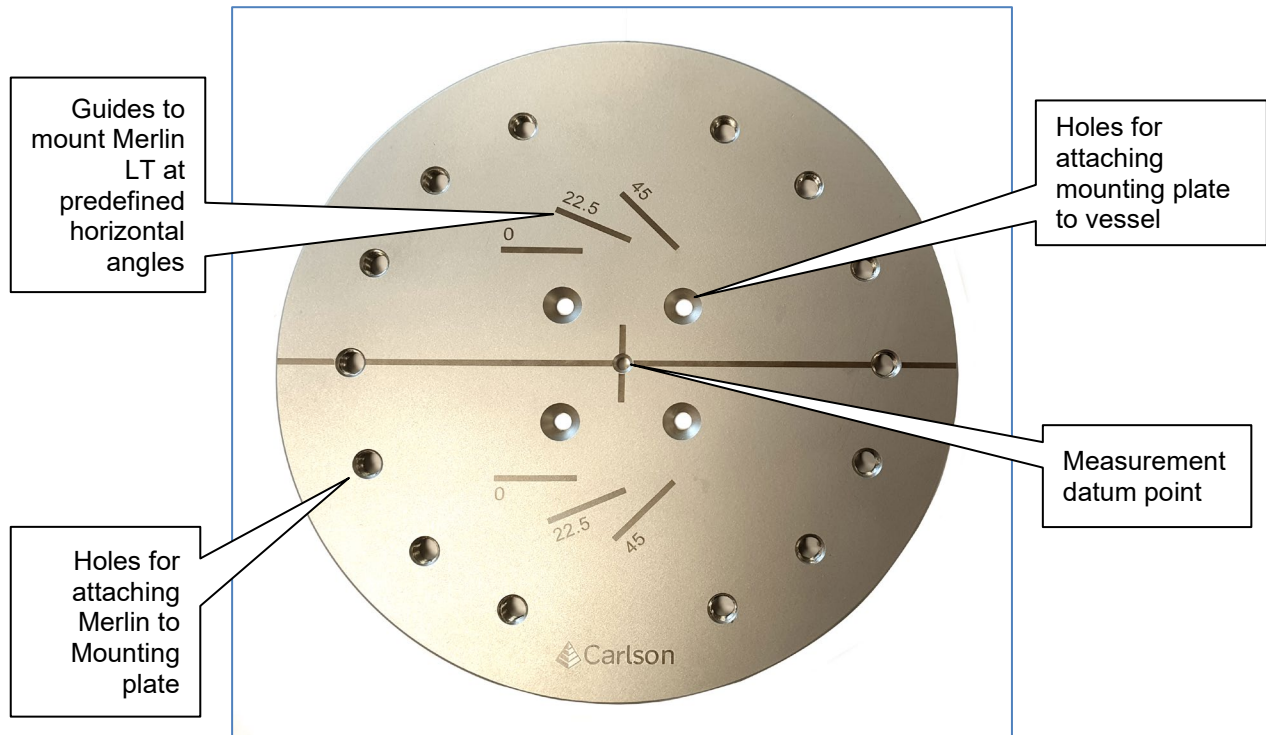

Guides to mount Merlin LT at predefined horizontal angles

Holes for attaching mounting plate to vessel

Holes for attaching Merlin to Mounting plate

Measurement datum point

Figure 13 Mounting plate

The mounting plate can be welded or bolted to the vessel infrastructure to provide a permanent base for the Merlin LT. The mounting plate should be installed aligned to the vessel centre line.

Predrilled, threaded holes provide locations to bolt the Merlin LT onto the mounting plate at different horizontal angles:

- 0°: produces scan lines perpendicular to the vessel. This gives the best range from the vessel's sailing line.

- 22.5°: rotation port and starboard. Produces horizontally offset scans which help when surveying features perpendicular to the vessel's sailing line – for example, the sides of buildings facing the vessel.

- 45°: rotation port and starboard. Produces horizontally offset scans which help when surveying features perpendicular to the vessel's sailing line – for example, the sides of buildings facing the vessel.

If the unit is moved horizontally, new lever arm values must be used. The heading calibration values must also be changed in your navigation package.

Use M5 countersunk bolts to secure the mounting plate to the vessel.

Use M8 bolts to secure the Merlin LT base plate to the mounting plate.

For details on using the mounting plate, see section 4.4.

4 Installation

This section of the manual describes a typical installation of the Merlin LT on a vessel, and its integration into the vessel's existing navigation system.

The installation workflow for a Merlin LT *without* the optional mounting plate is as follows:

1. Decide on a suitable mounting location for the Merlin LT on the vessel.

2. Orientate the Merlin LT parallel to the vessel centreline.

3. Secure the Merlin LT base plate in the selected mounting position.

4. Measure lever arms from the vessel's IMU reference point to the measurement datum point on the Merlin LT base plate.

5. Position the Merlin LT at the desired vertical angle.

6. Adjust and recalculate lever arms using the appropriate vertical laser offset adjustment.

7. Connect cables to Merlin LT.

   o Lay out and connect power cable to 12 Vdc power source.

   o Lay out and connect Ethernet cable to PC.

   o Lay out and connect PPS cable to PPS source.

   o Lay out and connect serial cable to ZDA source.

4.1 Choosing a mounting location for the Merlin LT

The location and mounting of the Merlin LT system on a vessel are important considerations in any installation. Before any work is carried out, due attention should be paid to the following:

- The Merlin LT is an optical device that relies upon a clear line of sight to the survey area. Ensure the field of view of the laser will not be restricted by any vessel infrastructure, such as railings, masts or antennas. This ensures that the Merlin LT will have a clear view to the survey area.

- The recommended Merlin LT installation location is often on the centre line, directly above the vessel cabin. Alternatively, the location can be on either side of the centre line, as close to the centre of gravity (CoG) as possible, and still with the Merlin LT parallel to the centre line.

- The location should be easy to access so that routine maintenance, inspection and re-orientation can be carried out regularly and without risk. A mast installation may offer the best line of sight but presents problems when the Merlin LT unit must be removed for servicing.

- The mounting location should be solid, free from vibration and rigidly secured with respect to the position of the vessel's IMU.

- Avoid dusty or dirty areas, such as engine room exhaust emissions, that may cause the lenses to become obscured.

- The mounting location must allow space for a 360° rotation of the head. An obstacle could block the movement and cause damage to the mechanical assembly.

- The location must be a suitable distance away from the power source, ZDA and PPS sources, and from the PC. This ensures that all the cabling can be routed in a safe, strain-free manner.

- The XYZ distance to the Merlin LT unit from an existing IMU or CoG must be accurately measured and recorded in the navigation software. When considering the location and orientation of the Merlin LT unit, it is important to ensure that it is possible to accurately measure this lever arm.

4.1.1   Orientation of the Merlin LT

It is recommended that the Merlin LT is installed in the same orientation as the vessel centre line, as shown in Figure 14. This simplifies the calibration process of Merlin LT. Care should be taken to align the base pate in an orientation parallel to the vessel centre line from bow to stern.
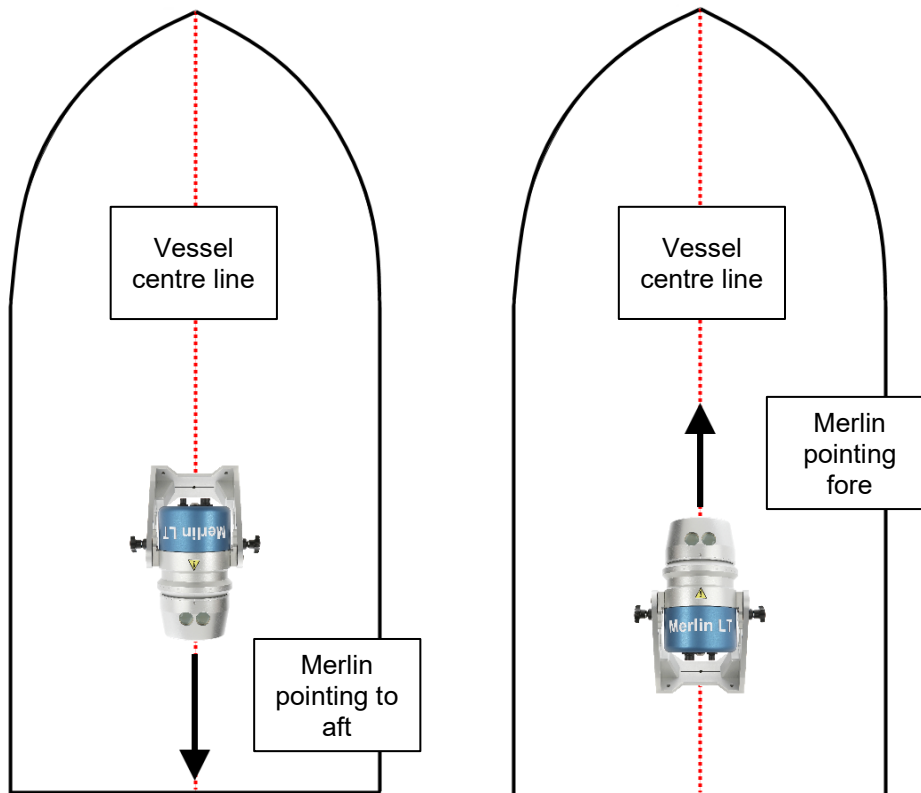
Figure 14 Orientation of the Merlin LT on the vessel

Note: The approximate heading value for the selected orientation will need to be applied in your navigation software. Refer to the accompanying navigation software quick-start guides for details on how to calibrate Merlin LT within QINSy, HYPACK, or PDS.

4.1.2   Securing the base plate

The base plate has four holes to allow the Merlin LT to be secured to the vessel.

The holes take M8 bolts. The use of Nyloc nuts is recommended for a stable, bolted installation.

Taking into account the criteria listed in the previous sections, position the base plate of the Merlin in the desired location, with the Merlin parallel to the vessel's centre line.

Mark out four M8-sized holes, using the base plate as a template. Drill the holes.

Use M8 bolts to secure the flange plate in position to a torque of 21 Nm.

When fixing the base plate in place, the Merlin LT must be secured absolutely rigid with respect to the vessel's IMU. If the platform to which the Merlin LT is mounted is flexible, vibrating, or not firm enough to take the weight of the unit, data collected with the Merlin LT is liable to be erroneous and to be mismatched with respect to data from other sensors onboard the vessel.

All drilling must be undertaken by a suitably trained engineer.

Use personal protective equipment, such as dust mask, eye protection and safety shoes.

Use the drill in accordance with the drill manufacturer's instructions.

Note that the optional mounting plate can provide a base which can be permanently installed on a vessel, making the process of mobilising and demobilising the Merlin LT itself much simpler: see section 3.6.1.

Use M5 countersunk bolts to secure the mounting plate to the vessel. Position the mounting plate so that the reference lines are parallel and perpendicular to the vessel's centre line.

Use M8 bolts to secure the Merlin LT base plate directly to the predrilled holes in the mounting plate.

4.1.3 Selecting a survey angle for the Merlin LT

There are three vertical angles at which the Merlin LT laser can be positioned. Changing the vertical angle can help to optimise the point cloud produced by the Merlin LT, specifically for your operation.

To set the desired vertical orientation, unscrew the two vertical locking studs - one on each side of the A-frame – to free the vertical pivot.

Figure 15 Unscrew the locking studs

With both locking studs undone, move the Merlin LT to the desired vertical angle.

Make sure that the vertical locking studs are in the correct lock position, then retighten them to secure the Merlin LT in place. No tooling should be used to tighten the locking studs – finger tight is adequate.

Do not attempt to alter the vertical angle when the Merlin LT laser is rotating. This could cause damage to the Merlin LT system and/or injury to the operator.

Once the locking studs are released the Merlin LT unit is free to pivot around the pivot point on the A-frame. Take care to avoid trapping fingers or clothing when altering the unit's vertical location.

4.2 Choosing an appropriate orientation

All projects are different, with their own set of unique challenges that need to be overcome. These challenges are never the same, but the Merlin LT's design offers the user several different scanning orientations which can provide scan patterns appropriate for your specific survey application.

It is important to ensure that the mounting orientation of the Merlin LT unit is correct from the outset of any specific project. Selecting the correct mounting angle will minimise shadows that cause gaps in the scan data and will ensure the best coverage of the targeted area. This will avoid the need to run extra survey lines, reducing cost and time.

Some of the considerations to take into account when selecting the orientation of the Merlin LT include:

- Range to the target from the vessel's sailing line;

- Angle of incidence of the laser with respect to the targeted surface;

- Foreground obstructions;

- The position, shape and orientation of the targeted objects or landscape.

Below are some recommendations that will help to assist in choosing the most appropriate mounting angle of the Merlin LT system for your specific project. Note that some projects would benefit from using the optional mounting plate which allows the Merlin LT to be mounted at fixed horizontal angles from the vessel's centre line: see section 4.4.

4.2.1 Example 1

When surveying features such as lampposts, telegraph poles, masts and marker posts along harbour walls or river channels, it is advised to have the vertical angle set to 45°. This allows the laser scan pattern to 'slice' through the vertical structure at an angle. A vertical angle of 90° could result in the feature being missed, as the 'slice' of data would be very close to vertical, and therefore in the same plane as the target object.

4.2.2 Example 2

When carrying out DTM (Digital Terrain Model) work – such as beach profiling along a coastline or flood-plain mapping along a canal or river – it is recommended to have the vertical angle set at 90° as this will give the greatest range either side of the vessel.

4.2.3 Example 3

When surveying buildings or man-made structures along a harbour wall or river, it is recommended to mount the Merlin LT unit at a 45° vertical angle, and to use the mounting plate to rotate the Merlin LT to a 22.5 or 45° horizontal angle.

By rotating the Merlin LT around the horizontal axis, the laser can view the façades of buildings and structures that run both perpendicular to and parallel with the direction of vessel travel.

4.3   Lever arm offset measurement

The purpose of this section is to outline the process necessary to calculate the lever arm, which is the position of the Merlin LT laser origin point in relation to the vessel's IMU/CoG. The laser origin point is inside the Merlin LT, at the centre point of the laser's horizontal rotation.

The lever arm is expressed as an XYZ coordinate on the vessel reference frame. This coordinate is entered into the navigation software and ensures that data from the Merlin LT is correctly positioned in relation to data received from other onboard sensors and survey equipment.

Note that a calibration must also be carried out prior to the start of survey operations in order to fine tune the heading, pitch and roll angles of the Merlin LT data with respect to the IMU. See the accompanying Merlin manuals for QINSy, HYPACK and PDS for further details on this process.

The workflow for carrying out the lever arm offset measurement is as follows:

- Secure the Merlin LT base plate in position.

- Establish the physical XYZ lever arm to the Merlin LT measurement datum point on the base plate.

- Position the Merlin LT at the desired vertical angle.

- Determine the vertical laser offset adjustment from Table 1.

- Apply the vertical laser offset adjustment to the measured XYZ lever arm.

- Enter the final lever arm into your navigation software.

The final lever arm values are dependent on the vertical angle at which the Merlin LT is positioned. These values will therefore change as the Merlin LT is reoriented vertically. Each time the unit is moved from its fixed position, new values must be accounted for and entered into the navigation software.

If the mounting plate is used, then a horizontal rotation may also need to be taken into account: see section 4.4.

4.3.1   Measuring the physical XYZ lever arm

Navigation software packages require an XYZ measurement from the vessel's IMU/CoG to the Merlin LT laser origin point. Since the laser origin point cannot be accessed for direct measurement, establishing this lever arm is carried out in two stages: a physical measurement to the visible Merlin LT measurement datum point in the centre of the base plate, followed by an adjustment taken from Table 1 which accounts for the offset from the measurement datum point to the laser origin point.

The measurement datum point is shown in Figure 16. This point must be physically measured as an XYZ offset from the IMU/CoG.
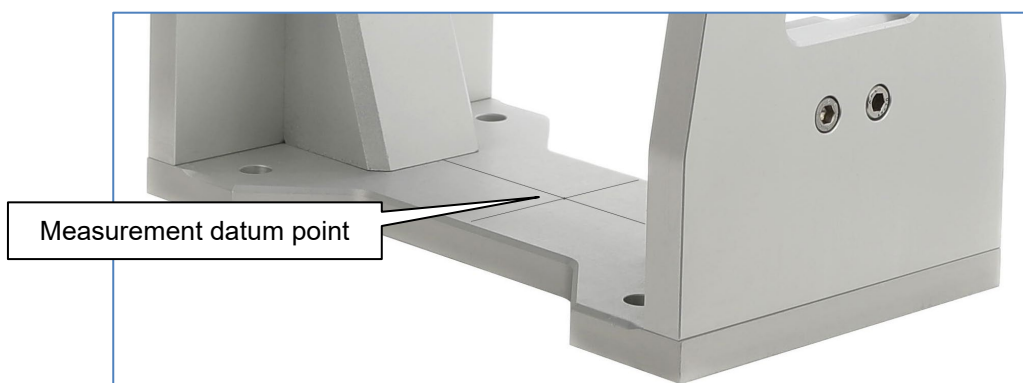
Figure 16 Merlin LT measurement datum point

Figure 17 shows a worked example of calculating the XY lever arm and indication of sign convention (positive/negative) when the Merlin LT system is mounted in two different positions. Other positions are acceptable.
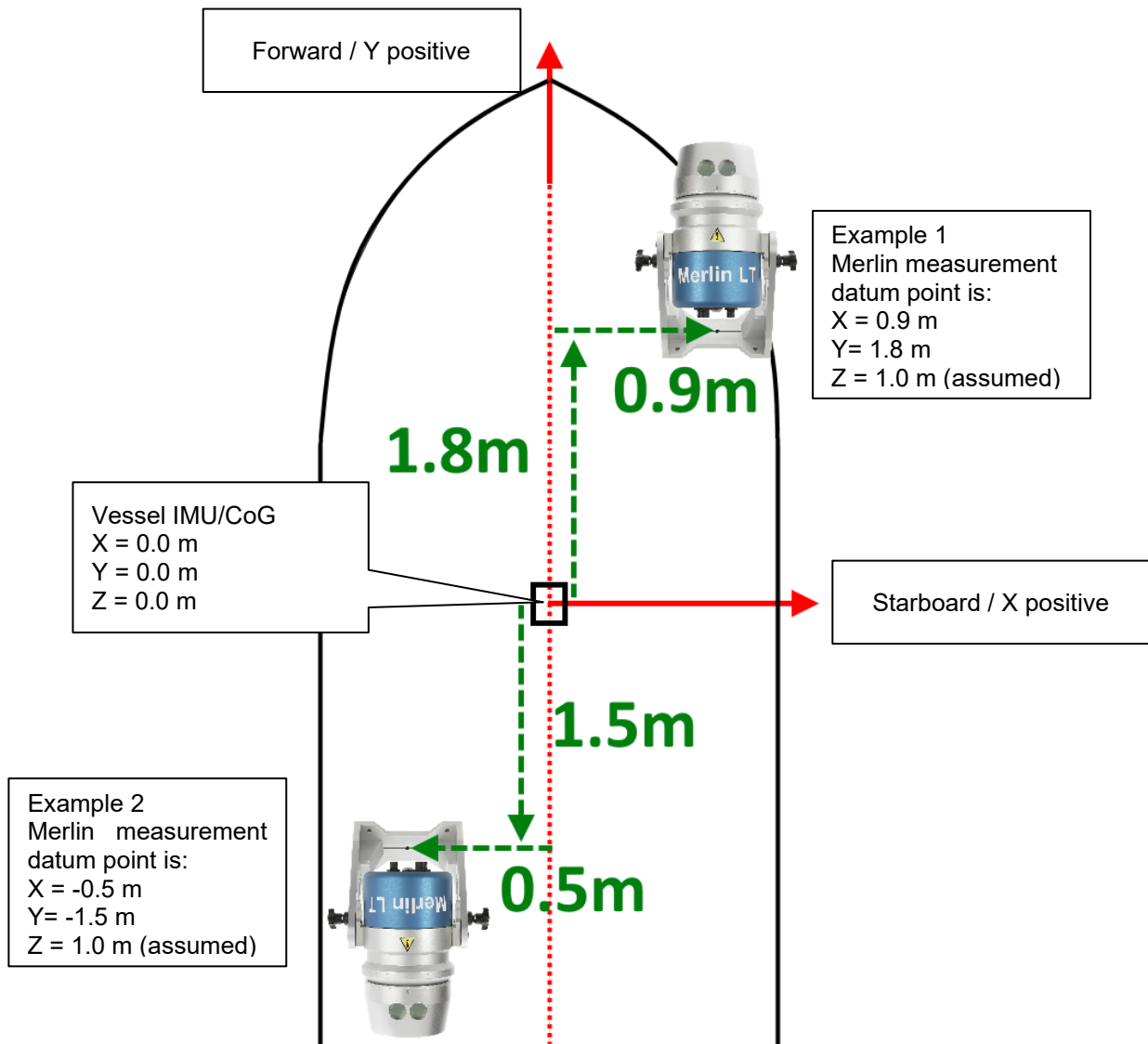

Figure 17 Examples of offsets to the Merlin LT measurement datum point

In the two examples, the measured offsets are:

- Example 1: X = 0.9, Y = 1.8.

- Example 2: X = -0.5, Y = -1.5

The Z / height value to the Merlin LT measurement datum point has been assumed to be 1.0 m, but this must also be measured from the IMU/CoG.

For this measurement, it does not matter whether the Merlin LT is facing fore or aft: the measurement is to the measurement datum point in the centre of the base plate.

Sign conventions may differ between different navigation packages.

The lever arm may be measured with a tape measure or with professional survey equipment. Either way, the suggested tolerance for measuring these distances is <5 mm. A measurement outside of this tolerance may result

in a lower quality calibration.

To establish the most accurate values it is recommended to carry out this measurement while the vessel is in a dry dock. If this is not practical, then the measurements can be taken from the nearest known point. For example, the XYZ lever arm of a nearby GNSS antenna may be known. The Merlin LT measurement datum point can therefore be offset from this point if it is easier than measuring all the way back from the IMU/CoG. However, the final lever arm values must always relate back to the IMU/CoG.

4.3.2 Determining the vertical laser offset adjustment

The vertical laser offset adjustment is the adjustment of the lever arm from the measurement datum point on the base plate to the laser origin point inside the Merlin LT.
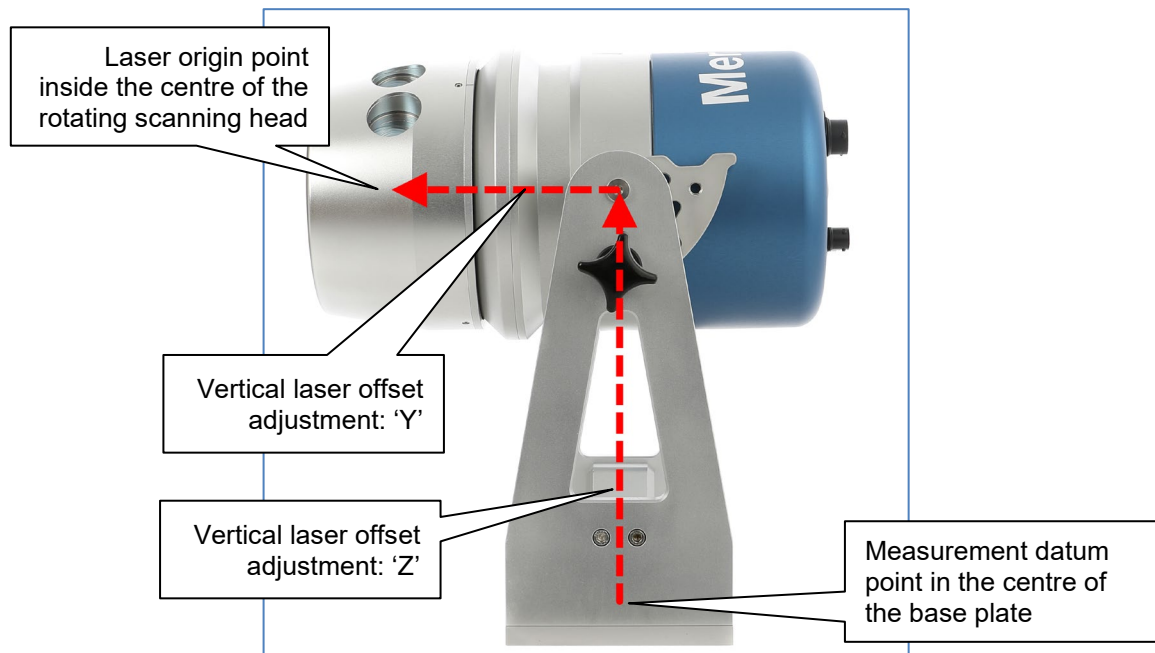

Figure 18 Vertical laser offset adjustment

The vertical laser offset adjustment is dependent on the vertical angle that the Merlin LT has been positioned at, and on the direction – fore or aft – that the Merlin LT is pointing on the vessel.

In the table below, select the relevant row according to the vertical angle at which the Merlin LT is secured. Then read off the XYZ values from the vertical columns, depending on whether the Merlin LT is facing fore or aft.

Measurements are in metres and are taken from the measurement datum point on the top of the base plate. To measure a vertical laser offset adjustment from the bottom of the base plate, add 0.01 m to the relevant Z value.

Merlin LT vertical angle	Merlin LT pointing aft			Merlin LT pointing fore		
	X	Y	Z	X	Y	Z
0	0	0	0.354	0	0	0.354
45	0	-0.082	0.302	0	0.082	0.302
90	0	-0.116	0.220	0	0.116	0.220

Table 1 Vertical laser offset adjustment

4.3.3 Apply the vertical laser offset adjustment to the measured XYZ lever arm

The vertical laser offset adjustment can now be applied to the initial physical XYZ lever arm measurement.

From the examples in section 4.3.1:

Example 1 – assuming the Merlin LT is set at 90° vertical angle:

- Measured offsets: X = 0.9, Y = 1.8, Z = 1.0

- Vertical laser offset adjustment (Merlin LT pointing fore; 90° vertical angle): X = 0.0, Y = 0.116, Z = 0.220

- Final lever arm offset: X = 0.9 m, Y = 1.916 m, Z = 1.220 m

Example 2 – assuming the Merlin LT is set at 45° vertical angle:

- Measured offsets: X = -0.5, Y= -1.5, Z = 1.0

- Vertical laser offset adjustment (Merlin LT pointing aft; 45° vertical angle): X = 0.0, Y = -0.082, Z = 0.302

- Final lever arm offset: X = -0.5 m, Y = -1.582 m, Z = 1.302 m

Take care to apply the negative / positive adjustments correctly.

4.4 Lever arm offset measurement when using the mounting plate

If you are *not* using the mounting plate, please skip this section.

The purpose of this section is to outline the process necessary to calculate the lever arm when using the optional Merlin LT mounting plate. The lever arm is the position of the Merlin LT laser origin point in relation to the vessel's IMU/CoG. The laser origin point is inside the Merlin LT, at the centre point of the laser's horizontal rotation.

The lever arm is expressed as an XYZ coordinate on the vessel reference frame. This coordinate is entered into the navigation software and ensures that data from the Merlin LT is correctly positioned in relation to data received from other onboard sensors and survey equipment.

Note that a calibration must also be carried out prior to the start of survey operations in order to fine tune the heading, pitch and roll angles of the Merlin LT data with respect to the IMU. See the accompanying Merlin manuals for QINSy, HYPACK and PDS for further details on this process.

The workflow for carrying out the lever arm offset measurement is as follows:

- Secure the Merlin LT mounting plate in position.

- Establish the physical XYZ lever arm to the measurement datum point on the mounting plate.

- Bolt the Merlin LT on the mounting plate at the desired horizontal angle.

- Position the Merlin LT at the desired vertical angle.

- Determine the vertical laser offset adjustment from Table 2 or Table 3.

- Apply the vertical laser offset adjustment to the measured XYZ lever arm.

- Enter the final lever arm into your navigation software.

The final lever arm values are dependent on the horizontal and vertical angles at which Merlin LT is positioned. These values will therefore change as Merlin LT is reoriented. Each time the unit is moved from its fixed position,

new values must be accounted for and entered into the navigation software.

The mounting plate allows the Merlin LT to be easily rotated horizontally by 22.5° or 45° clockwise (cw) or anticlockwise (acw): see Figure 13. This offers more flexibility in the way the Merlin LT can be positioned to view different targeted objects.

The mounting plate also provides a base which can be permanently installed on a vessel, making the process of mobilising and demobilising the Merlin LT itself much simpler.

Use M5 countersunk bolts to secure the mounting plate to the vessel. Position the mounting plate so that the main reference lines are parallel and perpendicular to the vessel's centre line.

4.4.1 Measuring the physical XYZ lever arm to the mounting plate

With the mounting plate secured in place on the vessel, the physical measurement of the XYZ lever arm should be carried out before the Merlin LT is fitted in position.

Navigation software packages require an XYZ measurement from the vessel's IMU/CoG to the Merlin LT laser origin point. Since the laser origin point cannot be accessed for direct measurement, establishing this lever arm is carried out in two stages: a physical measurement to the visible measurement datum point in the centre of the mounting plate, followed by an adjustment taken from Table 2 and Table 3 which accounts for the offset from the measurement datum point to the laser origin point.

The measurement datum point is shown in Figure 13. This point must be physically measured as an XYZ offset from the IMU/CoG.

Figure 19 shows a worked example of calculating the XY lever arm and indication of sign convention (positive/negative) when the Merlin LT system is mounted in two different positions. Other positions are acceptable.
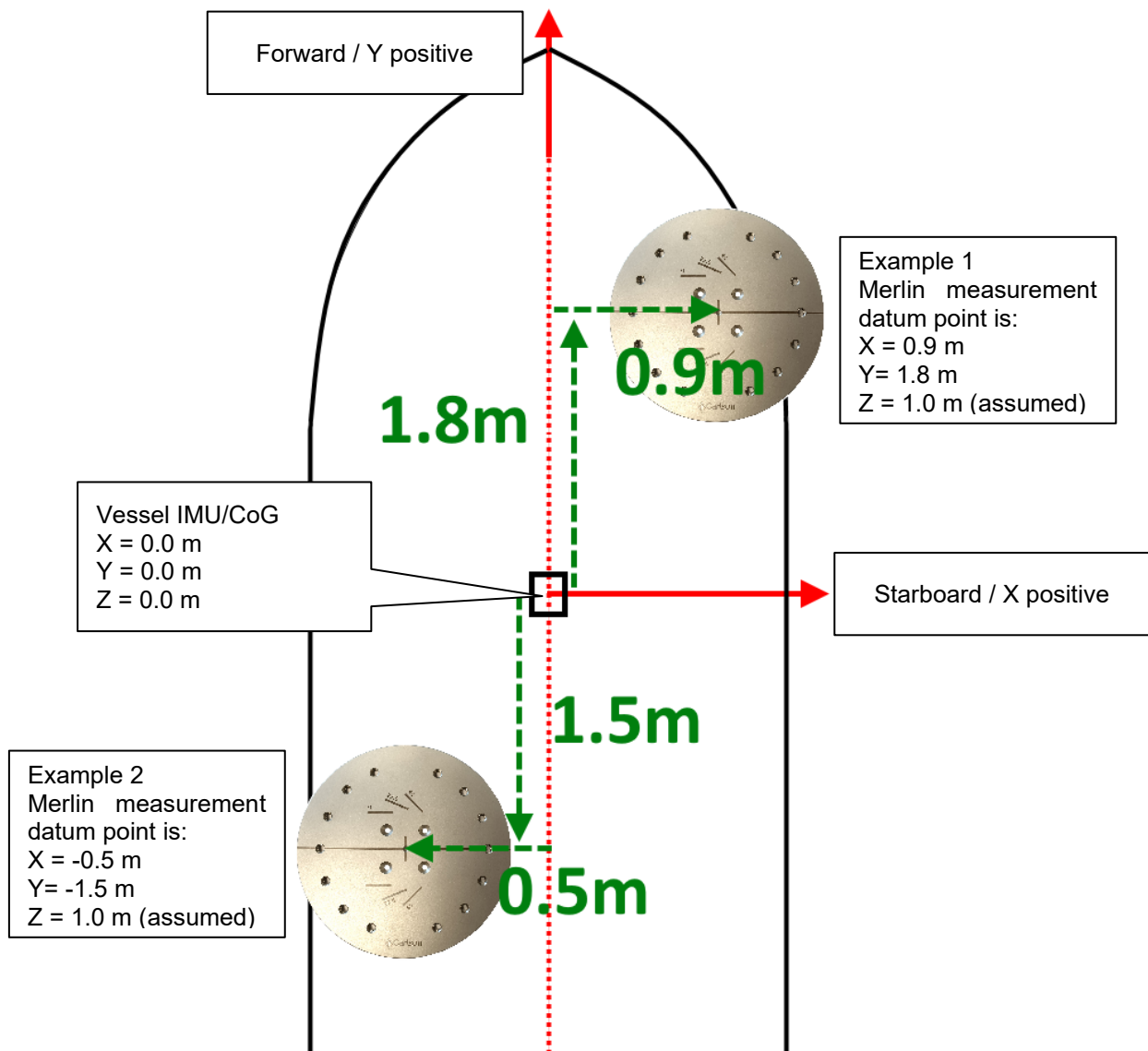
Figure 19 Examples of offsets to the mounting plate measurement datum point

In the two examples, the measured offsets are:

- Example 1: X = 0.9, Y = 1.8.

- Example 2: X = -0.5, Y = -1.5

The Z / height value to the mounting plate measurement datum point has been assumed to be 1.0 m, but this must also be measured from the IMU/CoG.

Sign conventions may differ between different navigation packages.

The lever arm may be measured with a tape measure or with professional survey equipment. Either way, the suggested tolerance for measuring these distances is <5 mm. A measurement outside of this tolerance may result in a lower quality calibration.

To establish the most accurate values it is recommended to carry out this measurement while the vessel is in a dry dock. If this is not practical, then the measurements can be taken from the nearest known point. For example, the XYZ lever arm of a nearby GNSS antenna may be known. The mounting plate measurement datum point can therefore be offset from this point if it is easier than measuring all the way back from the IMU/CoG. However, the final lever arm values must always relate back to the IMU/CoG.

4.4.2 Setting the Merlin LT orientation

The mounting plate displays guidelines to ease alignment of the Merlin LT at predefined horizontal angles. Predrilled, threaded holes provide fixed locations to bolt the base plate down at each of these angles.

Select your desired horizontal angle and bolt the Merlin LT in place.

Select your desired vertical angle and use the locking studs to secure the Merlin LT in place.

4.4.3 Determining the vertical laser offset adjustment

The vertical laser offset adjustment is the adjustment of the lever arm from the measurement datum point on the mounting plate to the laser origin point.

To the XYZ lever arm values, you must apply the vertical laser offset adjustment. The vertical laser offset adjustment is dependent on three variables:

- the direction – fore or aft – that the Merlin LT is pointing on the vessel;

- the vertical angle at which the Merlin LT has been positioned;

- the horizontal angle (cw or acw) that the Merlin LT has been rotated to on the mounting plate.

From Table 2 and Table 3 below, select the relevant table according to whether the Merlin LT is facing fore (Table 2) or aft (Table 3).

From the left-hand column select the vertical angle (45° or 90°) at which the Merlin LT is set.

Select the horizontal angle from the second column. The angle is 22.5° cw or awc, or 45°cw or acw.

Finally, read off the XYZ values from the vertical columns.

Measurements are in metres and are taken from the measurement datum point on the mounting plate.

Vertical angle	Horizontal angle		Vertical laser offset adjustment		
			X	Y	Z
90° (Merlin LT pod horizontal)	0	Facing fore	0	0.116	0.23
	22.5	acw	-0.044	0.107	0.23
	45	acw	-0.082	0.082	0.23
	22.5	cw	0.044	0.107	0.23
	45	cw	0.082	0.082	0.23
45° (Merlin LT pod inclined)	0	Facing fore	0	0.082	0.312
	22.5	acw	-0.031	0.076	0.312
	45	acw	-0.058	0.058	0.312
	22.5	cw	0.031	0.076	0.312
	45	cw	0.058	0.058	0.312

Table 2 Vertical laser adjustment - mounting plate used - Merlin LT facing fore

Vertical angle	Horizontal angle		Vertical laser offset adjustment		
			X	Y	Z
90° (Merlin LT pod horizontal)	0	Facing aft	0	-0.116	0.230
	22.5	acw	0.044	-0.107	0.230
	45	acw	0.082	-0.082	0.230
	22.5	cw	-0.044	-0.107	0.230
	45	cw	-0.082	-0.082	0.230
45° (Merlin LT pod inclined)	0	Facing aft	0	-0.082	0.312
	22.5	acw	0.031	-0.076	0.312
	45	acw	0.058	-0.058	0.312
	22.5	cw	-0.031	-0.076	0.312
	45	cw	-0.058	-0.058	0.312

Table 3 Vertical laser offset adjustment - mounting plate used - Merlin LT facing aft

4.4.4 Apply the vertical laser offset adjustment to the measured XYZ lever arm

The vertical laser offset adjustment can now be applied to the initial physical XYZ lever arm measurement.

Two examples are illustrated in Figure 20 below.

Example 1 – the Merlin LT is set at a 90° vertical angle and 22.5° cw horizontal angle:

- Measured offsets to mounting plate: X = 0.9, Y = 1.8, Z = 1.0
- Vertical laser offset adjustment
    - Merlin LT pointing fore, so refer to Table 2;
    - 90° vertical angle;
    - 22.5° cw horizontal angle
    - X = 0.044, Y = 0.107, Z = 0.230
- Final lever arm offset: X = 0.944 m, Y = 1.907 m, Z = 1.230 m

Example 2 – the Merlin LT is set at 45° vertical angle and 45° cw horizontal angle:

- Measured offsets: X = -0.5, Y= -1.5, Z = 1.0
- Vertical laser offset adjustment:
    - Merlin LT pointing aft, so refer to Table 3;
    - 45° vertical angle;
    - 45° cw horizontal angle;
    - X = -0.058, Y = -0.058, Z = 0.312.
- Final lever arm offset: X = -0.558 m, Y = -1.558 m, Z = 1.312 m

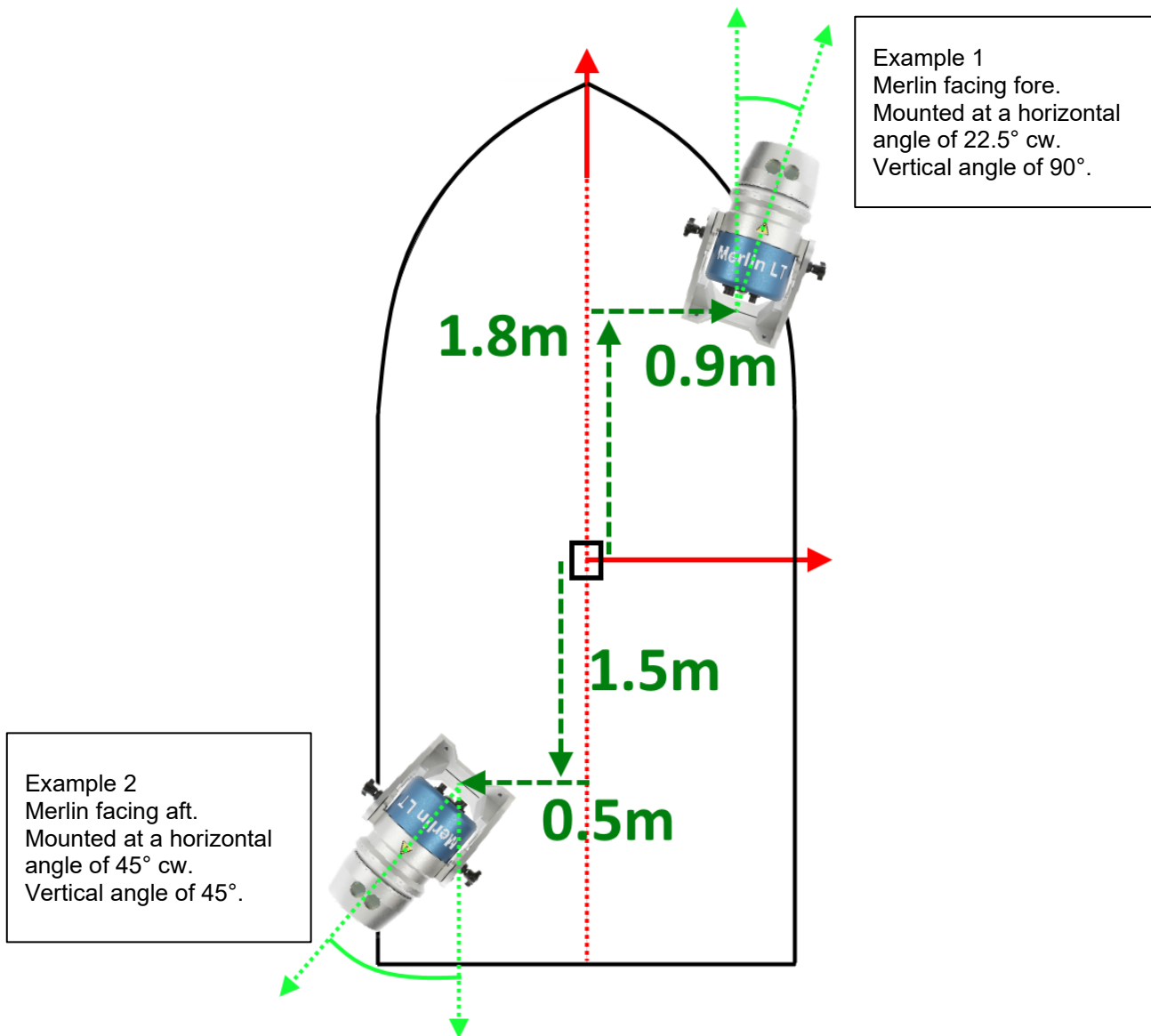Take care to apply the negative / positive adjustments correctly.

Example 1
Merlin facing fore.
Mounted at a horizontal angle of 22.5° cw.
Vertical angle of 90°.

Example 2
Merlin facing aft.
Mounted at a horizontal angle of 45° cw.
Vertical angle of 45°.

1.8m

0.9m

1.5m

0.5m

Figure 20 Examples of Merlin LT mounted with horizontal offsets

4.5 Cable runs

The Merlin LT system employs a simple cable arrangement: see section 3.2. As with any marine cable run, good practice is needed to ensure a successful installation.
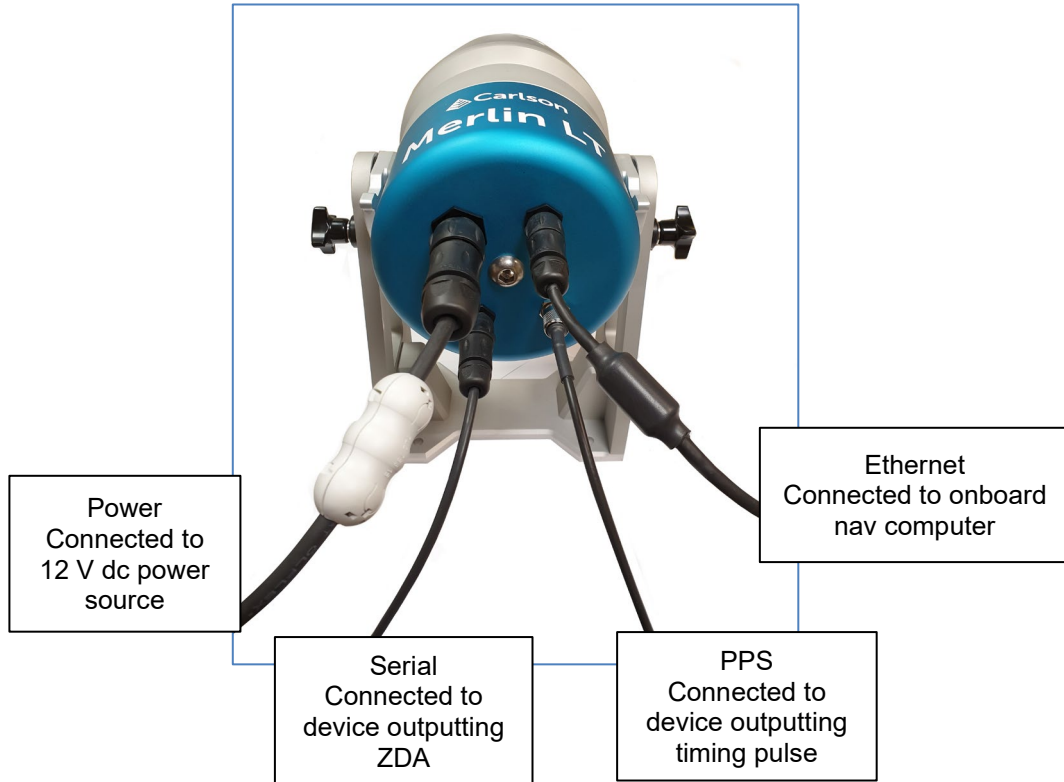
Figure 21 Merlin LT showing input sources

Ensure all cables are securely connected to the back of the Merlin LT. All connectors are unique so cannot be plugged into the wrong socket.

Ensure that all cables are secured in a safe manner along their entire length. Use cable ties or cable clips to keep them from obstructing walkways, doorways and emergency access points.

All cable runs should be protected as much as possible. The cables should be adequately secured and supported to ensure there is no free movement or damage to the cables.

Where there is enough cable, service loops should be left at both ends of each cable to allow for future work and/or relocation.

5 Electrical installation

Always isolate the dc power source before the unit is installed or uninstalled. Appropriate visual inspection and electrical safety testing must be performed after unit installation or unit replacement.

All batteries contain highly reactive, poisonous and corrosive chemicals, which are hazardous if released.

Should a battery approach end-of-life, become non-functional or be damaged, then it must not be used.

Do not attempt to open the Merlin LT.

The Merlin LT system has no user-serviceable parts. In the event of a problem, please contact Carlson.

The Merlin LT system must be powered from an external, low-voltage dc power source rated at 12 V dc, +/-0.5 V.

The characteristics of Merlin LT's electrical motor drive mean that a higher current is drawn at rotation start-up, stabilising when at a constant defined rotation speed. The current draw also becomes greater in colder temperatures. These are considerations when selecting the power supply to be used.

If a single Merlin LT unit is operating at 12 Vdc, it has the potential to draw up to 8.5 A at start-up.

Any voltage source connected to the Merlin LT system must be from a regulated supply and within the specified voltage range. This includes a car battery as an acceptable stand-alone power source, but it does not include a car battery connected to a powered vehicle or from a dc power generator.

The battery used should be capable of meeting the maximum power parameters of the system, as well as conforming to the required scanning duration.

A new, good quality, standard car battery of 80 Ah from fully charged should run a single Merlin LT unit for between 8 and 10 hours.

Dedicated connectors that fit the terminals of your chosen battery may need to be attached to the dedicated Merlin LT power cable if the supplied connectors are not appropriate.

Ensure there is a sound, low electrical resistance connection to the battery.

The power cable positive is the RED sleeved wire. If the red sleeving is not present, seek further advice from Carlson.

Do not extend the Merlin LT power cable.

5.1 Merlin LT Power cable

Details of the power cable supplied with the Merlin LT are outlined in the schematic and pin-out table below.
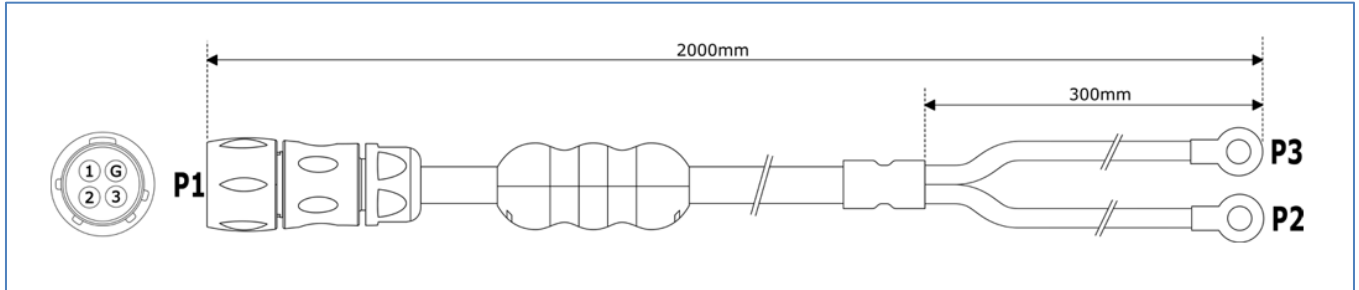

Figure 22 Merlin power cable schematic - connector pin view is of mating side

Connection	Wire list	Function	Connection
P1 Pin 1	Black 1	0 V	P2
P1 Pin 4(G)	Black 2	0 V	P2
P1 Pin 2	Black 3*	V+	P3
P1 Pin 3	Black 4*	V+	P3

Table 4 Power cable connections

6   Merlin LT time-tagging

The Merlin LT laser data is time-tagged by aligning an NMEA ZDA message to an accurate 1 pulse per second (PPS) timing pulse. Merlin LT has the ability to receive PPS and ZDA timing messages from certain external GPS receivers. This timing information is then integrated into the header of the UDP packet that contains the laser measurement data that is interpreted by the navigation software.

Time-tagging enables data from the Merlin LT to be accurately associated with corresponding position, heading and motion data collected from other sensors on the vessel.

6.1.1   ZDA input options

GPS manufacturers implement the ZDA and PPS signal slightly differently. Therefore, when inputting a timing source into Merlin LT from an external source the correct option must be selected from the **GPS Receiver Type** drop-down list in the **Configuration** window of the Merlin diagnostic tool software: see section 7.4.

The options in the **GPS Receiver Type** drop-down list are outlined below. These options may apply to equipment other than that specified by each label.

Trimble UTC: Trimble UTC data only; a valid string contains 26 characters. The laser expects the UTC string approximately 700 ms before the 1 PPS signal:

```
UTC 09.11.03 23:01:52 56<cr><lf>
```

Novatel Span: the laser will expect a valid data string to contain a 34-character string after the 1 PPS signal is active:

```
$GPZDA,043342.00,08,12,2009,,*64<cr><lf>
```

Novatel Coda: the laser will expect a 35-character string after the 1 PPS signal is active. The falling edge of the 1 PPS signal denotes the GPS time crossing the second boundary:

```
$GPZDA,043342.000,08,12,2009,,*64<cr><lf>
```

Merlin (Trimble ZDA): the laser will expect a 39-character string after the 1 PPS signal is active:

```
$GPZDA,161508.025,26,10,2010,00,00*5C<cr><lf>
```

Trimble Applanix: the laser will expect a 36-character string after the 1 PPS signal is active. The rising edge of the 1 PPS signal denotes the GPS time crossing the second boundary:

```
$GPZDA,212649.0039,31,08,2011,,*6E<cr><lf>
```

In the above examples <cr> represents the carriage return character and <lf> the linefeed character.

The time-tagged ZDA message coming from the external timing source needs to be correctly interfaced to the Merlin LT. When connecting the ZDA cable to the external source, the supplied cable configuration needs to be carefully considered in relation to the pins of the external source.

The supplied ZDA cable is designed to connect directly to industry-standard receivers. The expected connector on the external timing source is detailed in section 6.1.2 below.

6.1.2   External timing source: expected pin-outs

The external timing source should output the ZDA message through a serial cable with a male 9-pin, D-type connector (standard RS232 protocol).

Figure 23 and Table 5 show a serial connector and the expected pin-out schematic of the external timing source.
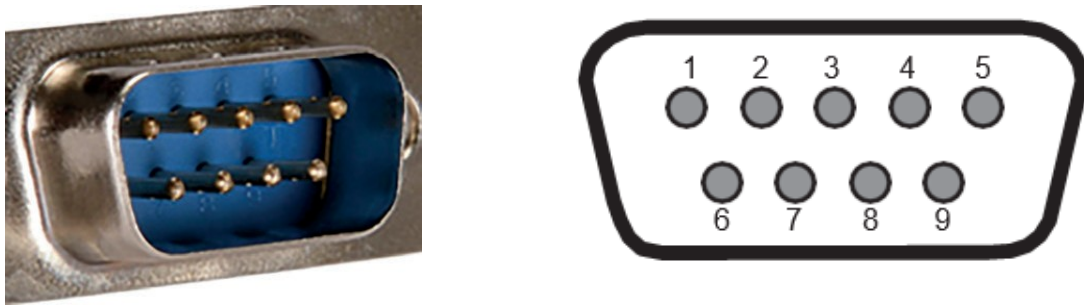
Figure 23 Male 9-pin, D-type connector (standard RS232 protocol) and pin-out schematic

Pin	Data	Description
2	Receive	
3	Transmit	Outputting a ZDA from the external timing source to Merlin LT
5	Ground	Common ground

Table 5 Standard RS232 protocols

6.1.3 Supplied ZDA cable pin-outs

Figure 24 and Table 6 below show the female 9-pin, D-type connector and pin-out schematic of the Merlin LT ZDA cable.

Figure 24 Female 9-pin, D-type connector of the Merlin ZDA cable and pin-out schematic

Pin	Data	Description	Direction
2	Transmit		Output
3	Receive	ZDA data received from external timing source into Merlin LT	Input
5	Ground	Common ground	

Table 6 Pin assignment of the Merlin ZDA cable

Both the Merlin LT and the external timing source should be configured at 115,200 baud, 8 data bits, no parity, 1 stop bit with no flow control.

The voltage levels of the PPS signal input to the Merlin LT should ideally be 0 Vdc to 3.3 Vdc.

Important notes:

- Understand the pin configuration of the external timing source being connected.

- If the pin configuration is standard RS232, communications will be correct.

- If the pin configuration is not compatible with the supplied ZDA cable, an adaptor cable will need to be sourced.

Contact Carlson for further assistance with interfacing the Merlin LT.

7 Operation of Merlin LT

The workflow below shows a basic set-up operation, using the Merlin diagnostic tool software.

1. Apply power to the Merlin LT.

2. Confirm or configure network connections.

3. Confirm or configure the timing protocol in the diagnostic tool software.

4. Start the Merlin LT laser to confirm time-tagging, communications and laser ranges are correct.

5. Close the Merlin diagnostic tool software and connect the Merlin LT to your navigation software.

7.1 Network set-up

The method used to communicate with the Merlin LT is through an Ethernet connection with a PC. The correct Ethernet parameters need to be established, namely IP ('Internet Protocol') address and subnet mask.

Each Merlin LT is first delivered with a pre-set IP address of 192.168.0.201 for the laser.

For first-time installation, communication needs to be correctly established between the PC and Merlin LT. This requires the PC to have an IP address on the same subnet as the Merlin LT unit.

Go to **Control Panel** > **Network and sharing centre** > **Change adaptor settings**. Double click on the connection you are using to connect to the Merlin LT.

This opens the relevant **Ethernet Properties** window.
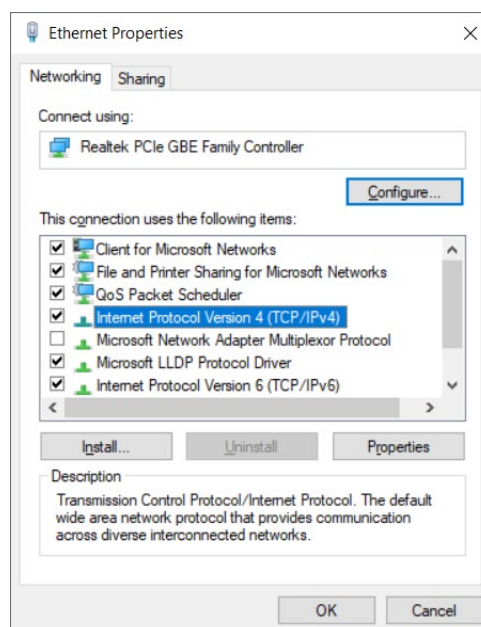
Figure 25 Ethernet Properties window

Double-click on **Internet Protocol Version 4 (TCP/IPv4)**.

The **Internet Protocol Version 4 (TCP/IPv4) Properties** window appears.
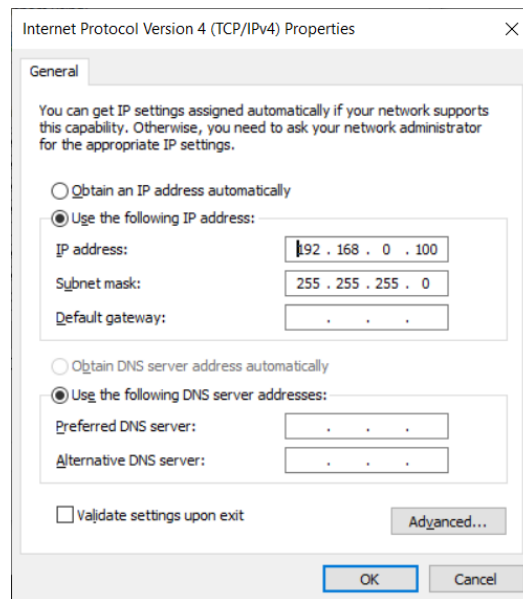
Figure 26 Internet Protocol Version 4 (TCP/IPv4) Properties

Enter the IP address of the PC in the **Use the following IP address** section. Enter an IP address which is the same as that of the Merlin LT except for the last three digits, which need to be a different number between 1 and 254. This must exclude the numbers currently in use for the Merlin LT unit and any other equipment on that subnet.

For example, using a Merlin LT with a default IP address of 192.168.0.201, enter an IP address of 192.168.0.100 for your PC, as in Figure 26.

Enter a Subnet mask of 255.255.255.0.

Note: It is important that both the IP address and subnet mask are entered correctly. Any deviation from this will result in the PC and Merlin LT not communicating with each other.

7.2 Pinging the Merlin LT laser

In order to check the initial communication with Merlin LT, 'ping' the Merlin LT laser by opening a Windows command prompt window: see Figure 27. To do this, type **CMD** into the Windows search bar and select **Command Prompt**.

The Command Prompt window will appear. Using the IP address of the Merlin LT laser, type:

```
ping 192.168.0.201
```

Then press **ENTER**.
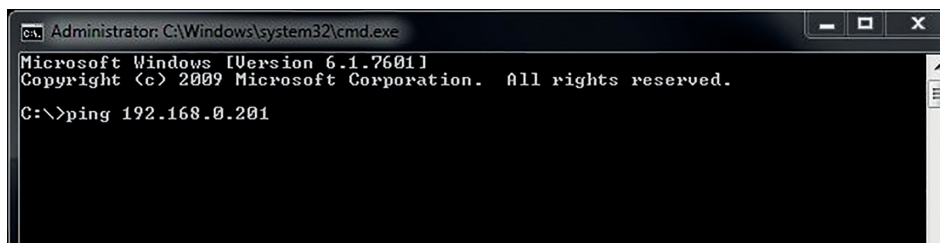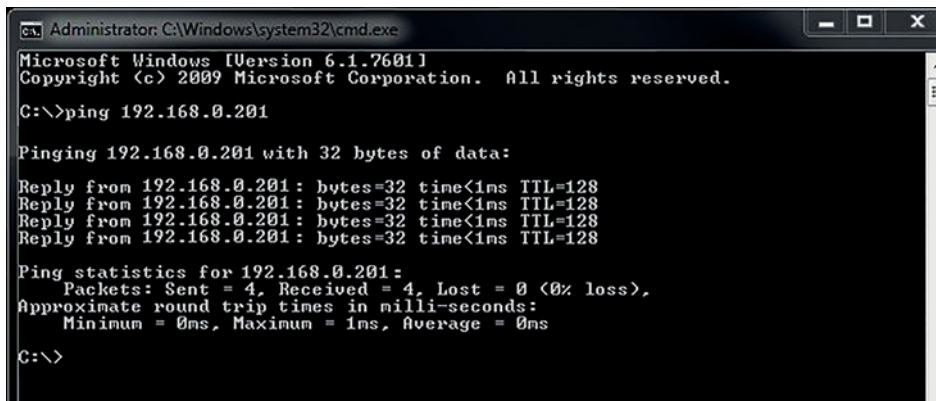
Figure 27 Windows command prompt

If the Merlin LT is correctly connected, a reply from the Merlin LT laser is received.

Figure 28 Receiving a reply from the Merlin LT

If the reply says 'unreachable', then there is a communication issue. Check the Merlin LT power source, the hardware cable connections and the IP addresses of the Merlin LT and PC to make sure everything is correctly configured.

7.3 Changing the Merlin LT network settings

To integrate the Merlin LT into an existing vessel infrastructure of IMUs, GNSS receivers and bathymetric sensors correctly, it is possible that the Merlin LT IP address will need to be changed from the factory-set value.

To change the IP address of the Merlin LT, follow the procedures in this section.

7.3.1 Connecting to the Merlin LT

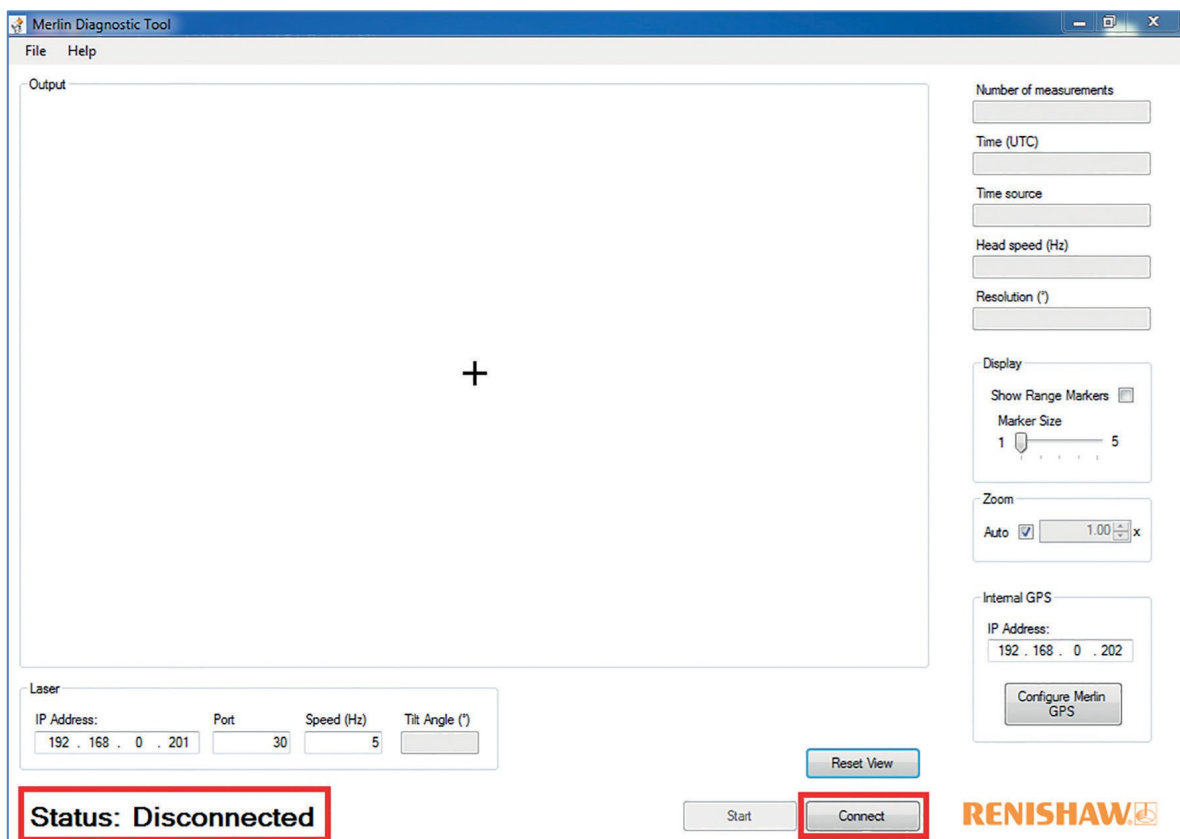Start the Merlin diagnostic tool software. The Merlin diagnostic tool main window appears.

Figure 29 Merlin diagnostic tool software – Status: Disconnected

The Laser section in the bottom left-hand corner of the window contains the IP address and Port text entry boxes for the Merlin LT laser. These automatically populate with the default (or last saved) values. Check these values are the current known values of the Merlin LT.

The **Status: Disconnected** message is displayed.

Press **Connect** to connect to the Merlin LT laser.

The **Status: Connecting** message is displayed.

Note: communication may take up to two minutes to initialise.

Once connected successfully, the **Status: Idle** message is displayed: see Figure 30.
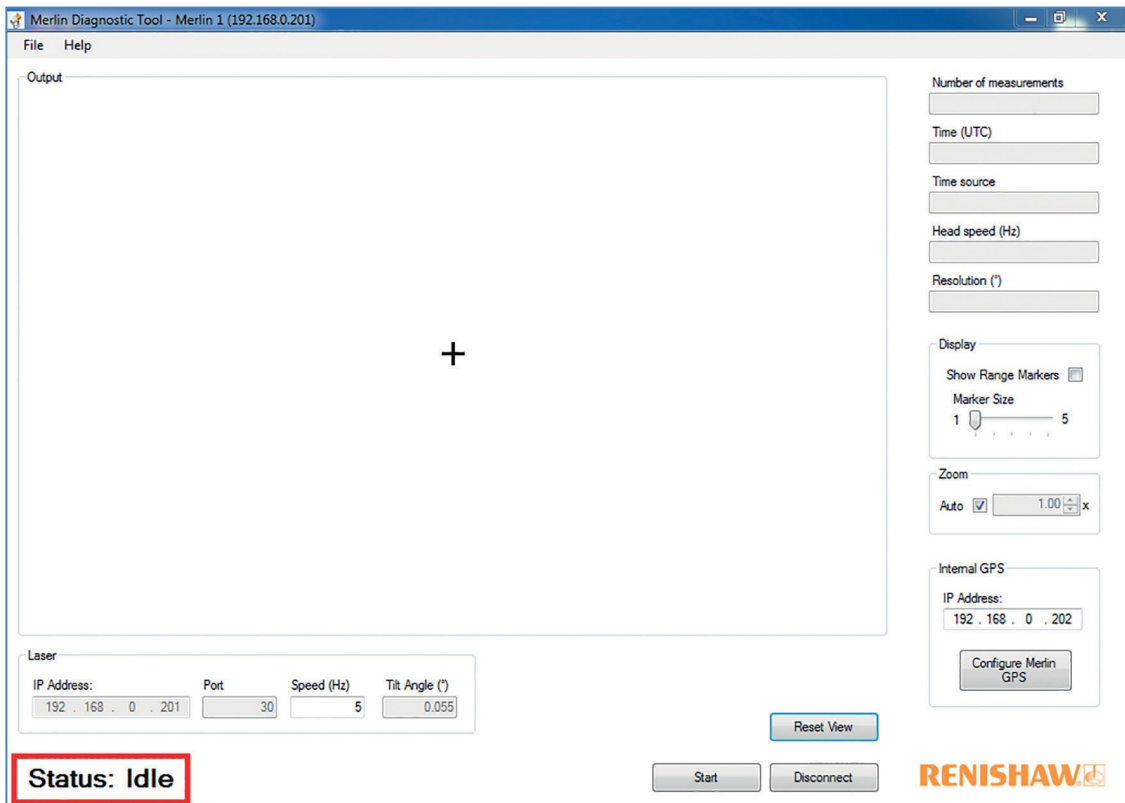
Figure 30 Status: Idle

Note: if the connection continues to be unsuccessful, a **Connect Error** warning is displayed: '*Unable to connect. Please check the connection parameters and try again*'. In this case, check the following:

- the network parameters of the laser;

- the LAN settings of the PC;

- all physical cable connections.

7.3.2 Changing the Merlin LT IP address

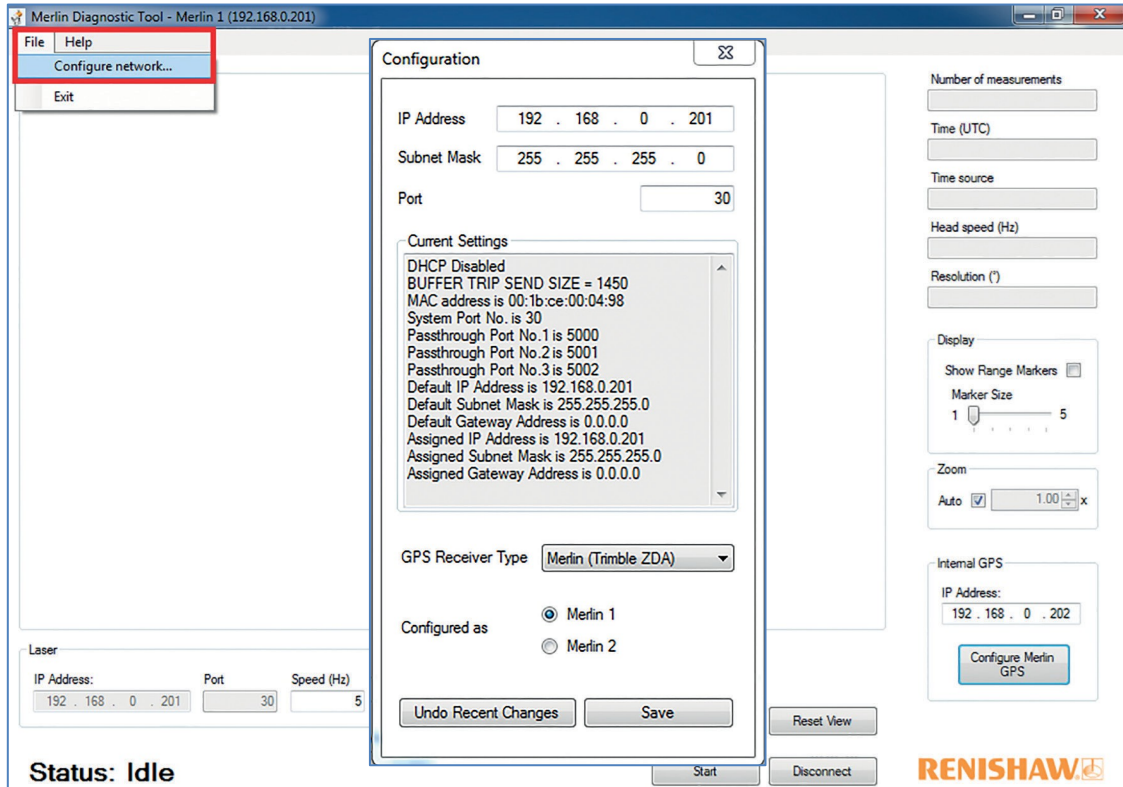In the main Merlin diagnostic tool window click **File** > **Configure Network.** The **Configuration window** appears.

Figure 31 Opening the Configuration window

Enter the IP address and/or Port number to a new value to fit into the existing vessel network.

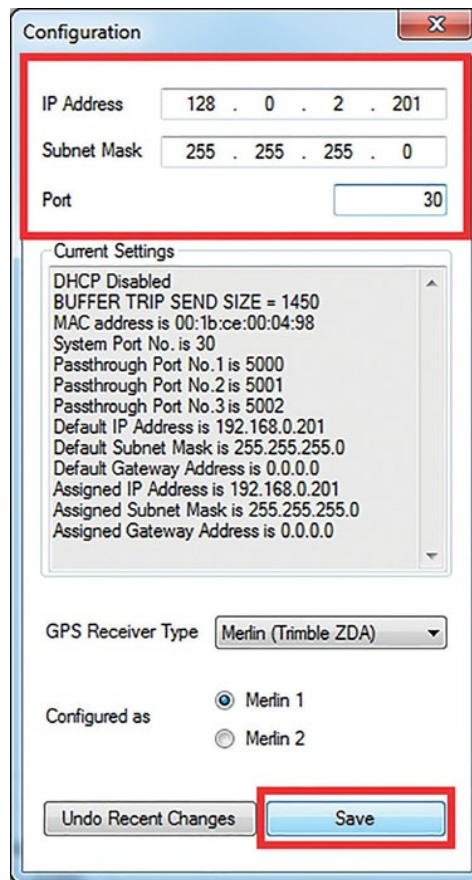In the example in Figure 32, the new IP address is 128.0.2.201.

Figure 32 Entering a new IP address in the Configuration window

Click **Save** to save the changed IP address.

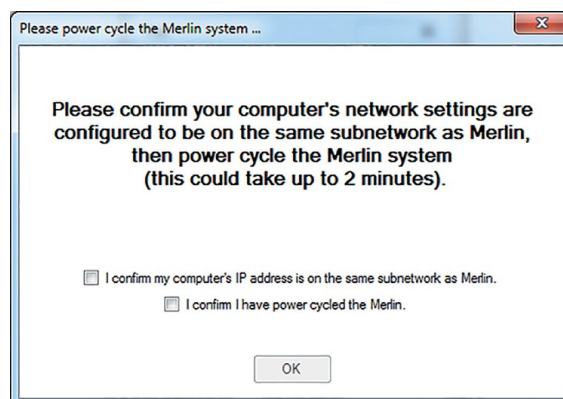A message appears prompting you to confirm the IP address and to power cycle the system.

Figure 33 Prompt for changing the IP address

At this stage do not select the tick boxes.

7.3.3 Changing the PC IP address

If the Merlin LT subnet has changed significantly, for example from 192.168.0.201 to 128.0.2.202, the PC LAN settings need to be updated so that communications between the PC and Merlin LT can continue.

To change the PC's IP address, follow the same procedure as in section 7.1.

Go to **Control Panel** > **Network and sharing centre** > **Change adaptor settings**. Double click on the connection you are using to connect to the Merlin LT.

This opens the relevant **Ethernet Properties** window.

Double-click on **Internet Protocol Version 4 (TCP/IPv4)**.

The **Internet Protocol Version 4 (TCP/IPv4) Properties** window appears.

Enter an IP address for the PC. This IP address should be same as that of the Merlin LT except for the last three digits, which should to be a different number between 1 and 254. This IP address must be different from all other devices currently in use on the selected network.

In Figure 34, an IP address of 128.0.2.100 has been selected for the PC, to conform with the address of 128.0.2.201 for the Merlin LT system.
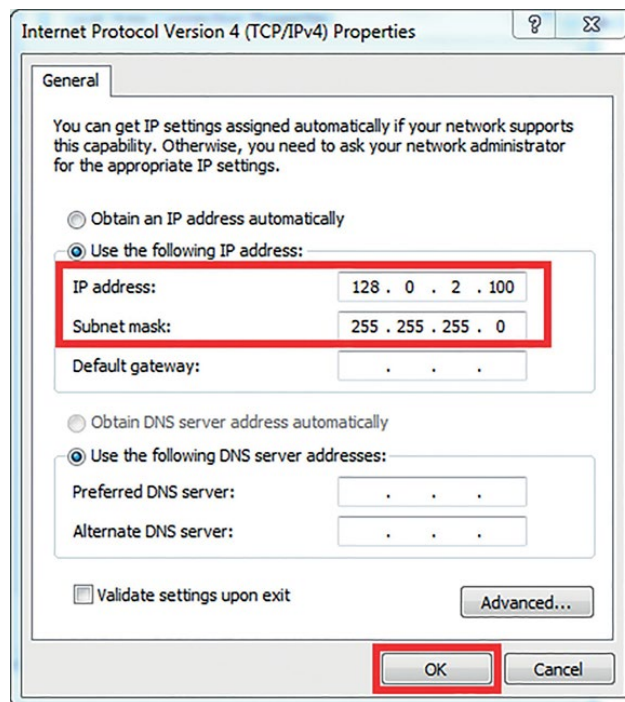

Figure 34 Changing the PC IP address

Having set the new IP address for your PC, click **OK** and return to the Merlin diagnostic tool software.

7.3.4 Power cycle and reconnect to the Merlin LT

Having changed the IP addresses of the Merlin LT and of the PC, power cycle the Merlin LT by disconnecting and then reconnecting the power source.

By power cycling the system, communications to the PC will be lost and a reconnection occurs using the new IP addresses.

In the Merlin diagnostic tool, the **Please power cycle the Merlin LT system**…message window is still visible.

Tick the check box beside the statement '*I confirm my computer's IP address is on the same subnetwork as Merlin'*.

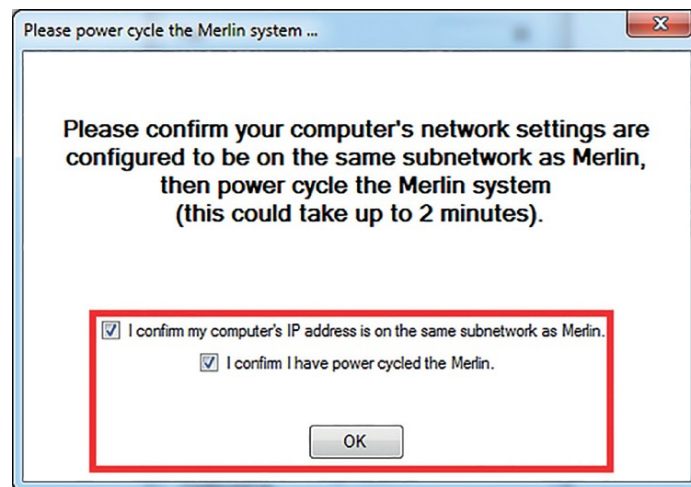Tick the check box beside the statement *'I confirm I have power cycled the Merlin'*.

Figure 35 Confirm you have power cycled the Merlin LT

Click **OK** to return to the main Merlin diagnostic tool window.

Note: when you click **OK**, the connection with the Merlin LT is lost. It could take up to two minutes for the LAN connection to re-establish.

The system must be reconnected by clicking **Connect**, as described in section 7.3.1.

The **Status: Idle** message is displayed: see Figure 30.

If you have changed the IP address of the Merlin from the default, factory-set value, make sure you note the new IP address and make all users aware of the change. If you contact Carlson for support, detail the changed IP address to your support contact.

7.4 Setting up Merlin diagnostic tool software to receive external timing

In the Merlin diagnostic tool, select **File** > **Configure network.** The **Configuration window** opens.
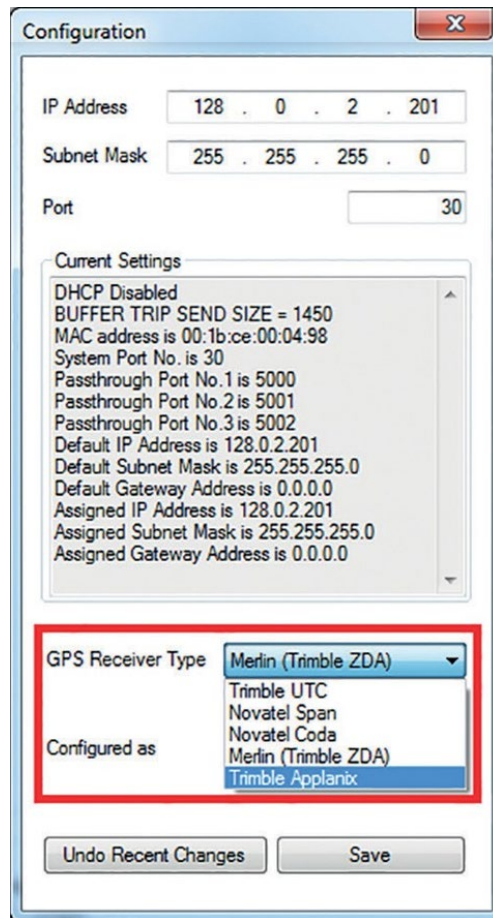

Figure 36 GPS receiver type drop-down list

Click the **GPS Receiver Type** drop down list to access the available types of receivers.

Select the timing source option matching your hardware set-up from the protocols, as detailed in section, 6.1.1.

Note: In this example the external timing source selected is **Trimble Applanix**.

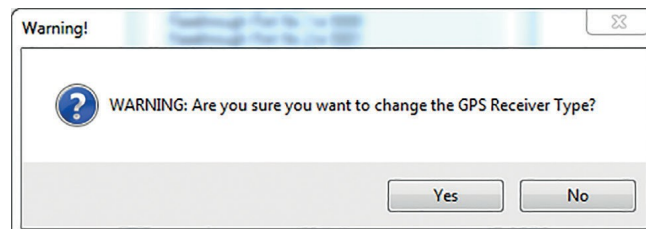Click **Save**. A **Warning** window appears.

Figure 37 Changing the GPS receiver type

If the new selection is correct, click **Yes**, then close the Configuration window.

If the new selection is incorrect, click **No** and reselect the appropriate **GPS receiver type**.

Note: The drop-down list does not contain an exhaustive list of GPS receivers on the market and there is a chance that your specific timing source may be incompatible with the Merlin LT. In this case, contact Carlson for further information.

7.5 Checking the laser operation

It is essential that you verify the raw laser data prior to operation in your navigation software. This section describes how to do this in the Merlin diagnostic tool software.

Ensure that the Merlin LT is connected to the Merlin diagnostic tool software: see section 7.3.1.

With the **Status: Idle** message displayed, click the **Start** button.

⚠️ WARNING: Beware of the contact/impact potential when the laser is rotating.
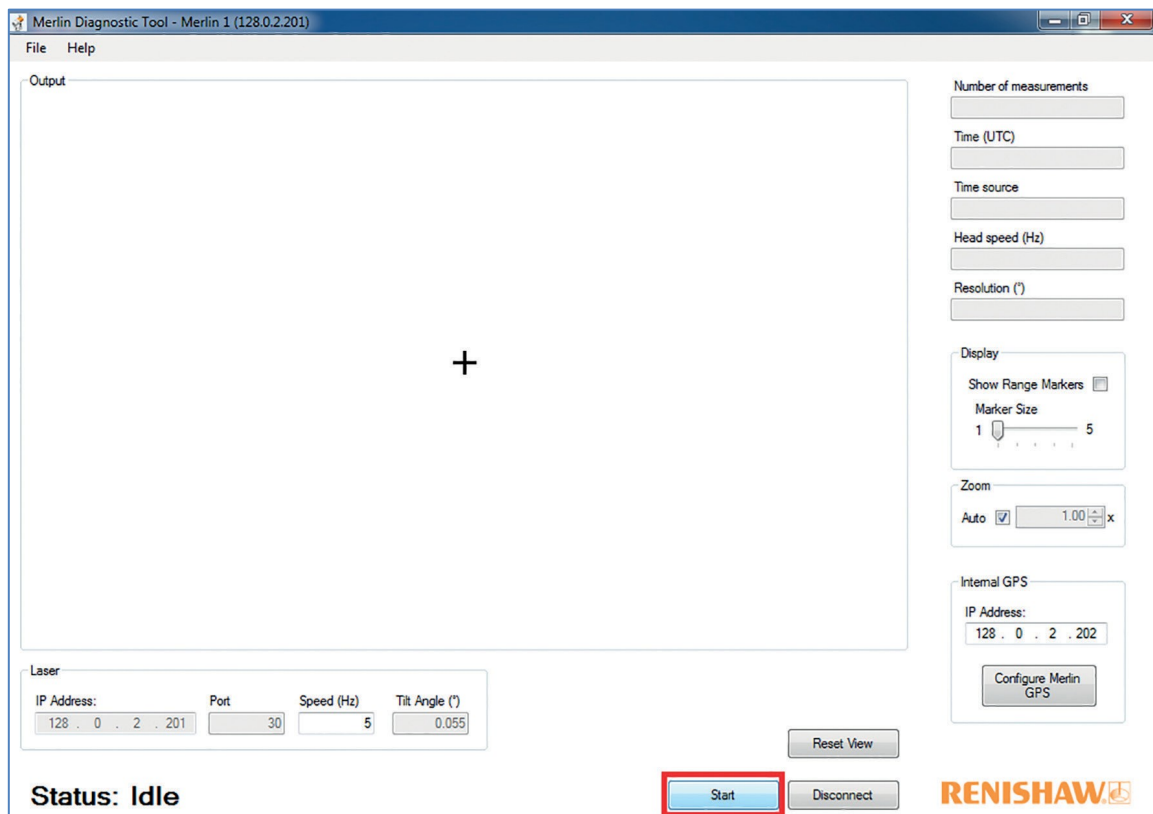

Figure 38 Starting the Merlin LT laser

Once the laser is rotating, the section of points collected during the current rotation is displayed in the **Output** frame.

The points are joined together and displayed as a red line which reflect the current view of the Merlin LT laser.

The maximum and minimum ranges recorded by the laser in each section are displayed in the top left of the **Output** frame.
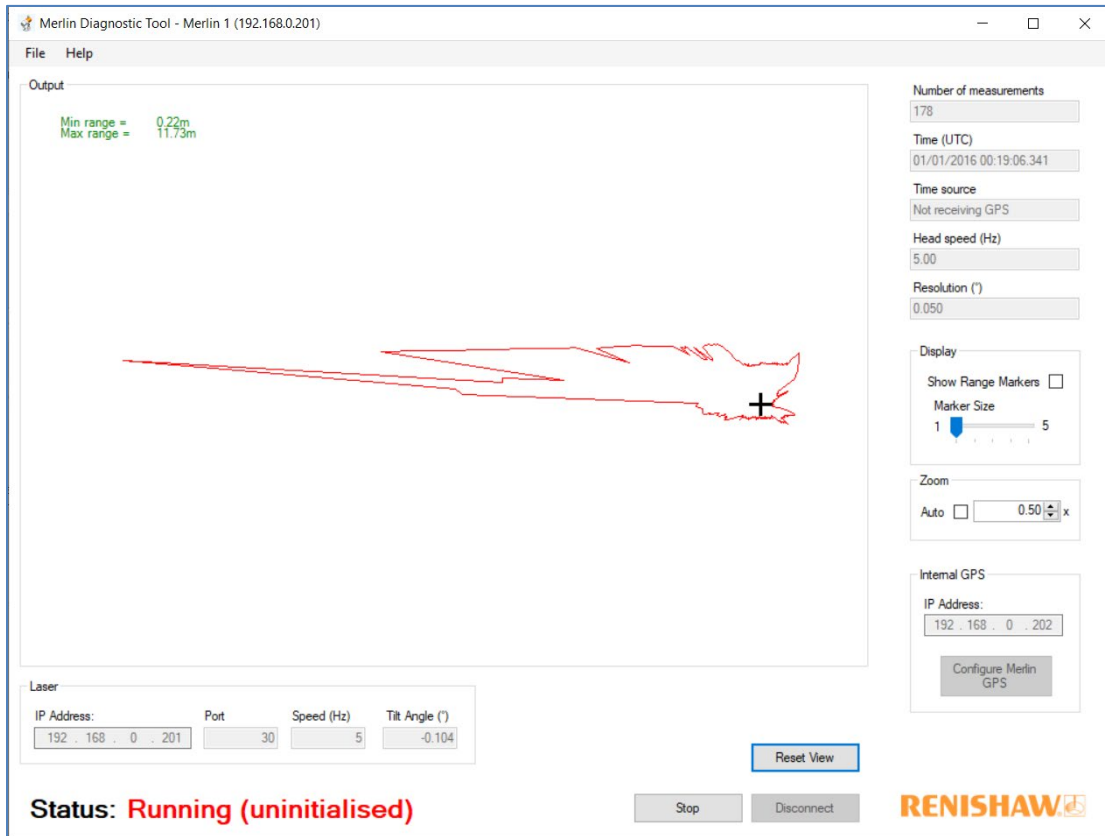
Figure 39 Merlin LT laser display

7.5.1 Merlin LT laser range finder rotation speed

The Merlin LT laser records 36,000 points per second and can rotate to a speed of 20 Hz (20 revolutions per second). The navigation software drivers enable this rotation speed to be changed during operations.

You can also change the laser rotation speed when using the Merlin diagnostic tool. This can help to verify correct mechanical operation prior to connection to the navigation software.

To change the laser rotation speed, prior to starting the laser enter a value 1 – 20 in the **Speed (Hz)** text entry box. This is found within the **Laser** frame of the main Merlin diagnostic tool window: see Figure 40.
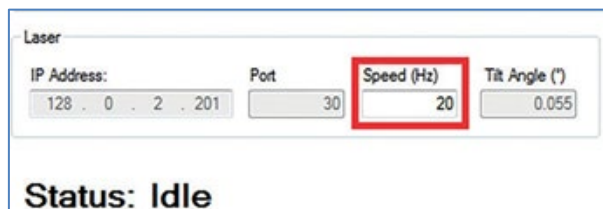

Figure 40 Laser rotation speed setting

With the correct speed set, click **Start** to start the laser rotating.

7.6 Checking the timing source

It is essential that you verify the timing inputs prior to operation in your navigation software. This section describes how to do this in the Merlin diagnostic tool software.

To understand if timing is being successfully received and processed by the Merlin LT, the Merlin diagnostic tool displays three main indicators:

- Status;

- Time source;

- Time (UTC).

For these three indicators to be active, the Merlin LT must be connected and the laser rotating.

7.6.1 Possible scenarios

Table 7 and the following text and screenshots highlight the possible scenarios relating to timing received by the Merlin LT.

Timing description	Status	Time source	Time (UTC)	Figure
Timing successful	1. Running (GPS:.......)*	GPS	Current date and time	Figure 41
Timing successful, then dropped	2. Running (synced, no GPS)	Not receiving GPS	Current date and time	Figure 42
Timing dropped and not recovered	3. Running (uninitialised)	Not receiving GPS	Current date and time	Figure 43
Timing never received	4. Running (uninitialised)	Not receiving GPS	01/01/2000 00:00:00.000	Figure 44
Timing being received. Wrong protocol	5. Invalid Time	Blank	Blank	Figure 46

Table 7 Possible scenarios with the Merlin LT timing

- For survey operations, the only acceptable Status message is **Running (GPS….)**. If the Time source is shown as **GPS**, both a valid PPS and ZDA message are being received. (* After 'GPS' the selected timing source is indicated, e.g. Trimble Applanix.). See Figure 41.

- If the Status is **Running (synced, no GPS)** this means the Time source has been **GPS** but that a GPS outage has occurred: see Figure 42. The laser data continues to be time-tagged but a valid GPS sync is not present. The Status reverts to **Running (uninitialised)** after 30 seconds..

- If the Status has been displayed as **Running (uninitialised)** from initial power-up, the Time source is **Not Receiving GPS**, but the Time (UTC) is the current date and time, this indicates an issue with PPS. See Figure 43.

- If the Status has been displayed as **Running (uninitialised)** from initial power-up, the Time source is **Not Receiving GPS**, the Time (UTC) is 01/01/2000 00:00:00.000, this indicates no valid timing is being received. See Figure 44.

- If Status is **Invalid Time** a ZDA message is being received but the protocol is set incorrectly. For example, if the protocol is set at Merlin (Trimble ZDA) but a Trimble Applanix protocol is being supplied, this would result in an invalid timing message. See Figure 46.
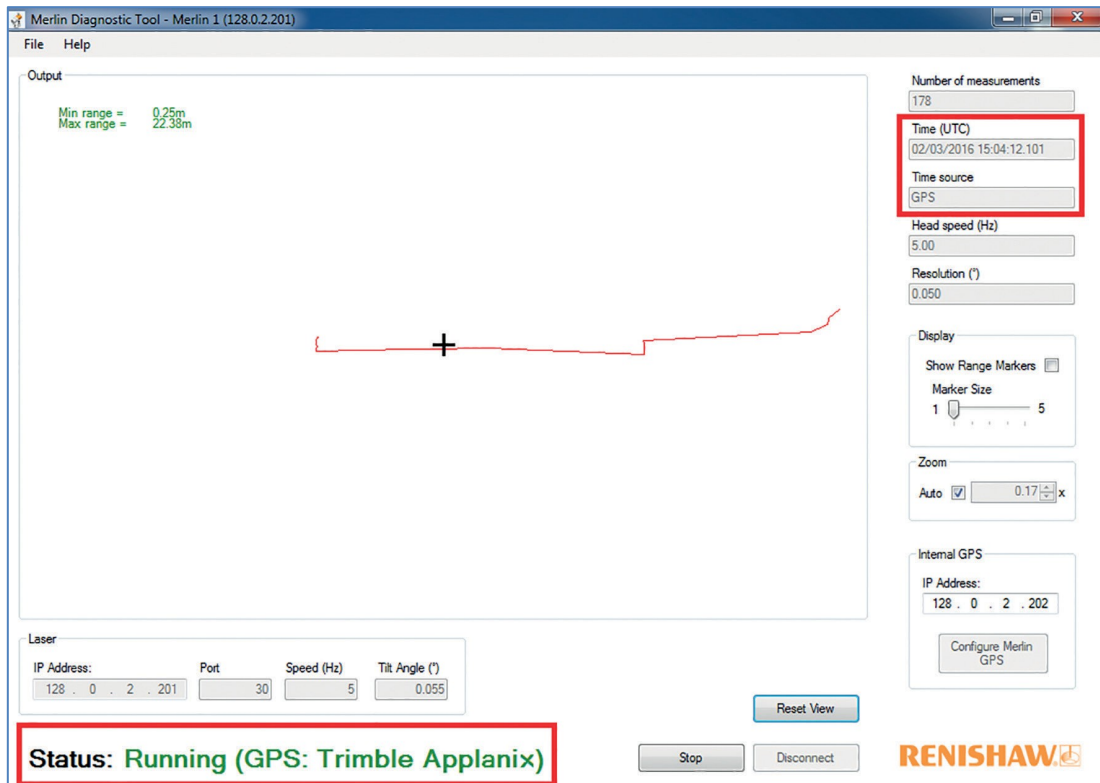
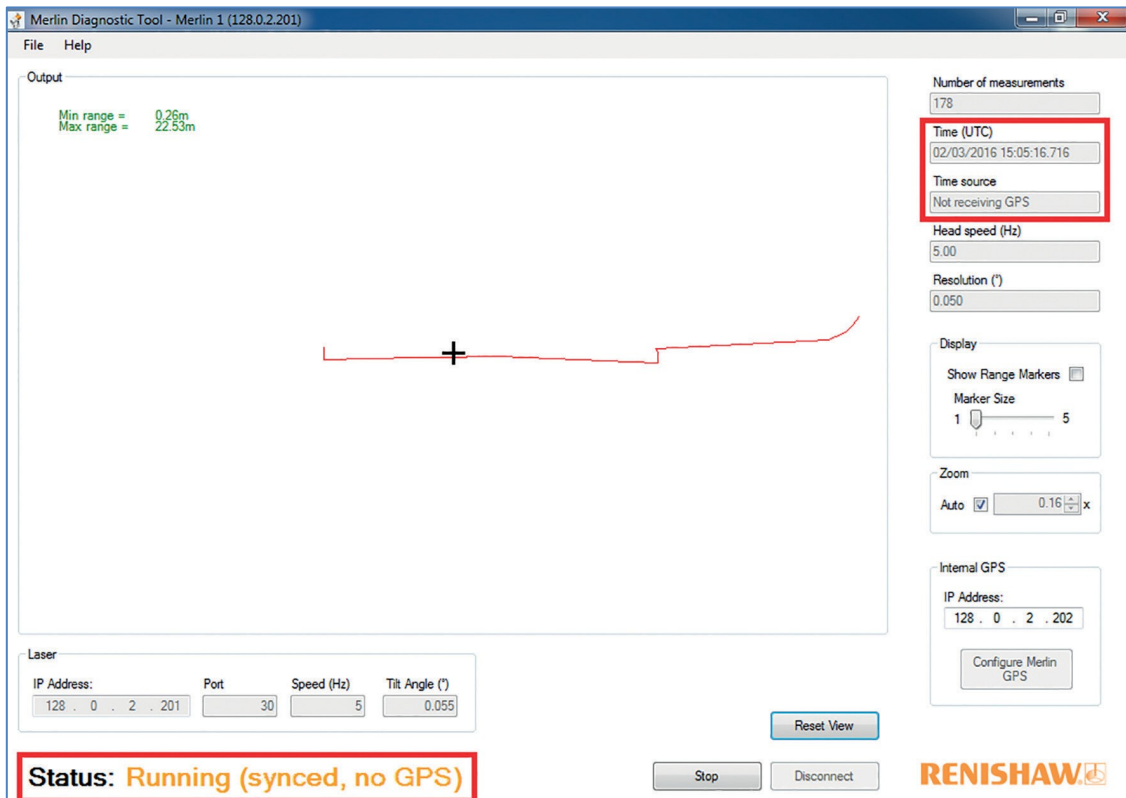*Figure 41 Status: Running (GPS...)*

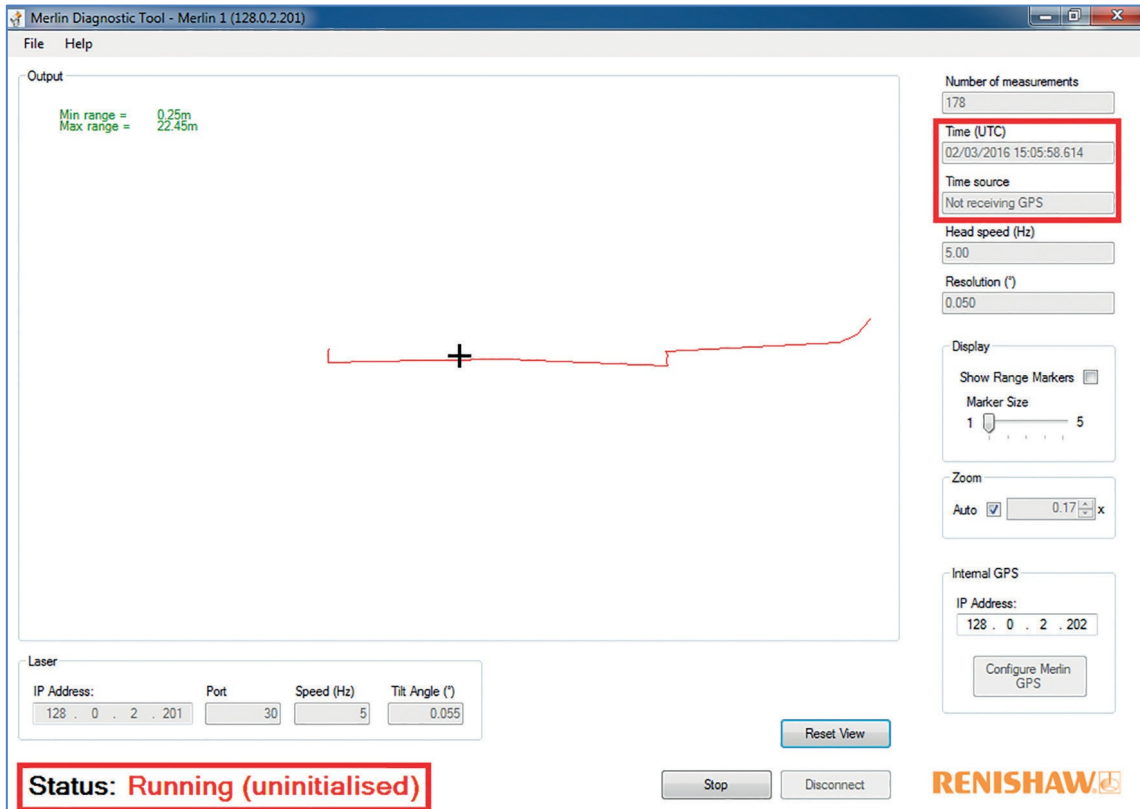*Figure 42 Status: Running (synched, no GPS)*

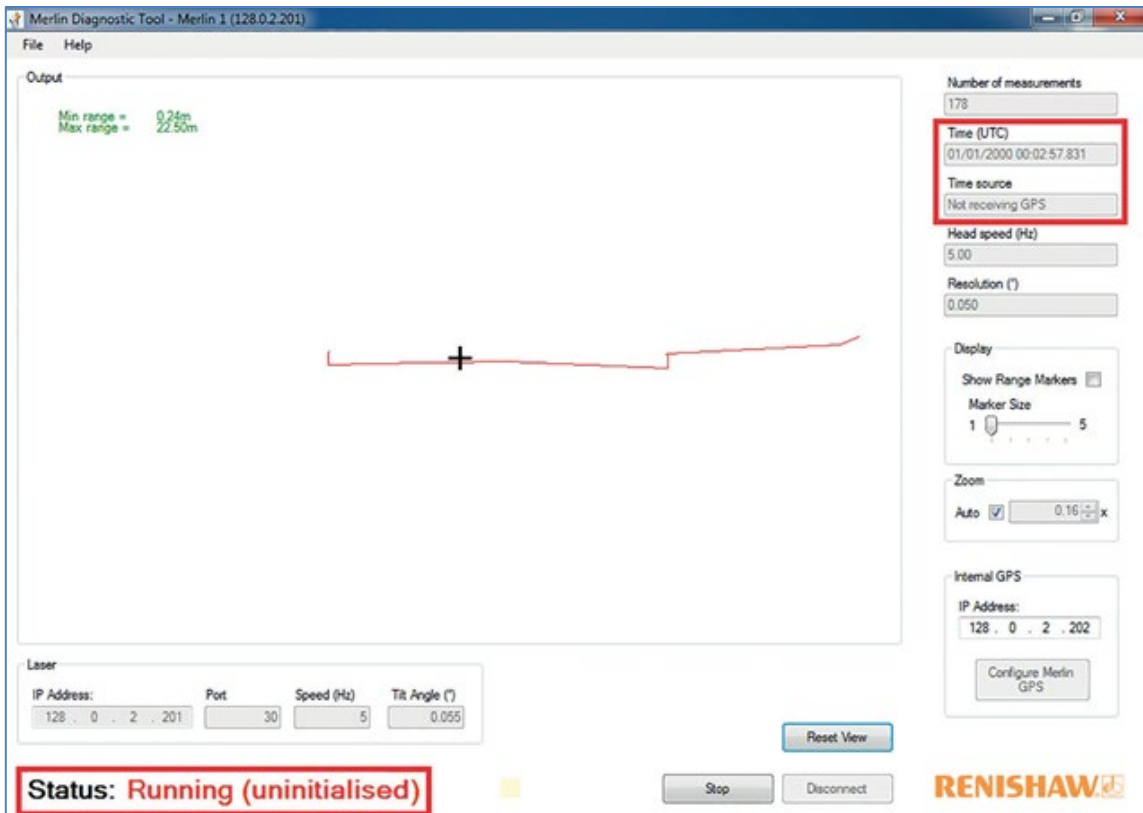*Figure 43 Status: Running (initialised) / Time (UTC) current*

Figure 44 Status: Running (uninitialised) / Time (UTC) 01/01/2000

Note: If timing is never received, a warning appears: see Figure 45. The listed actions should be verified to resolve the timing issue.
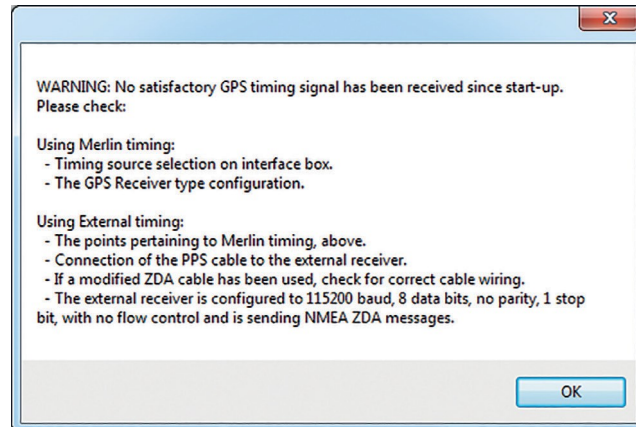

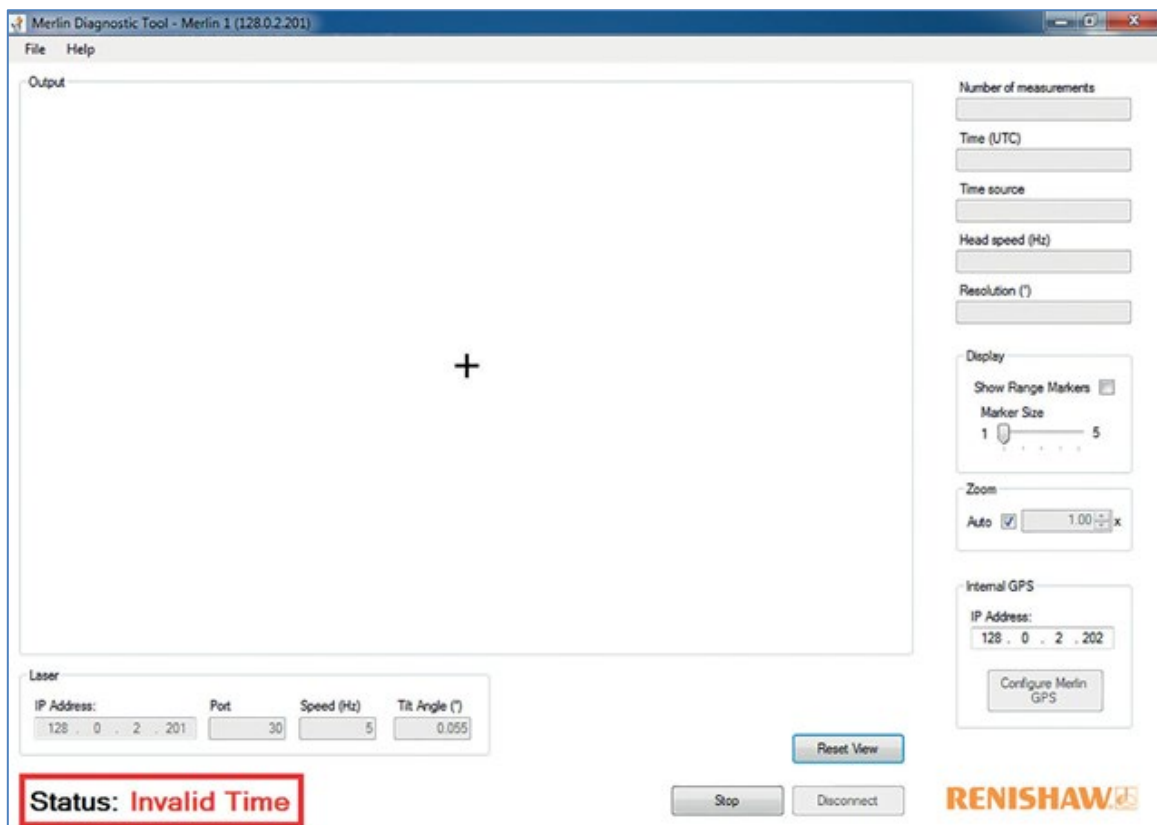*Figure 45 Warning message: no timing received*

Figure 46 Status: Invalid time

7.7   Other functions of the Merlin diagnostic tool software

The Merlin diagnostic tool software helps to check and set up the Merlin LT.

Basic functionality to view and control the presentation of the Merlin LT laser data is outlined below.

There are two sections on the right-hand side of the main display window that provide **Display** and **Zoom** options.

The **Display** section allows you to add/remove range markers in the **Output** frame. Range markers indicate individual points collected by the Merlin LT.

To activate or deactivate range markers, Tick the **Show Range Markers** check box. If the range markers are activated when the Merlin LT laser is rotating, markers appear in the **Output** frame at the location of each response from the laser. These circle markers can be increased or decreased in size using the **Marker Size** slider bar.
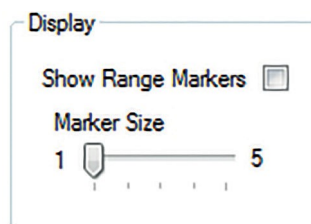

Figure 47 Display tools

The **Zoom** section allows the user to zoom in and out of the laser section displayed in the **Output** frame when the laser is rotating.

An **Auto** check box enables automatic zooming of the **Output** frame to the full extent of the laser section.

Figure 48 Zoom tools

When using a mouse, the view of the data in the **Output** frame can be altered. Use the middle scroll wheel to zoom the display in or out. Click and drag with the right button to pan the display.

7.8   Navigation software

Once the correct timing and IP addresses have been set in the Merlin diagnostic tool and the laser has been successfully checked, stop the laser rotation by pressing the **Stop** button.

Disconnect the Merlin LT from the Merlin diagnostic tool by clicking **Disconnect**. Close the Merlin diagnostic tool software.

The Merlin LT is now ready to connect to your navigation software.

The operation of the Merlin LT system in the compatible navigation software will vary with each package. A series of quick-start guides have been produced to help the user set up the Merlin LT when using these packages.

For assistance in setting up and operating the Merlin LT system, refer to the quick-start guide for the specific navigation software that you are using.

You may also refer to the navigation software company's own help resources for further information.

8 Maintenance and care of Merlin LT

8.1 General

Any attempt to dismantle or repair the Merlin LT system and accessories by unauthorised personnel can be hazardous and costly. Maintenance carried out by the operator should be restricted to the cleaning and inspection of external surfaces, lenses and operating controls.

8.2 Preventative maintenance

Preventative maintenance should include the following.

8.2.1 In use

- Avoid directing the Merlin LT laser towards the sun or other high-powered, infrared light sources.

- Avoid mechanical shock.

- The Merlin LT system is approved to IP66 EN 60529 : 1992 + A1 : 2002 and EN 60945 : 2002. It must not be submerged.

- Clean and dry the equipment before, during and after use. Use dedicated lens-cleaning wipes to clean the windows on the laser module.

- Ensure the locking screws are securely in place so that the Merlin LT vertical motion is locked when in use or when being moved.

- When moving the Merlin LT, use the A-frame to carry and support the Merlin LT wherever possible.

- Do not use paint solvents to clean the outer structure of the instrument. Use a mild detergent to clean the outer structure of the system or HPLC-grade isopropyl alcohol (propan-2-ol) solution, applied with a lint-free cloth, to clean the lenses.

8.2.2 In storage

- Dry the system thoroughly before storing.

- Correctly pack the equipment in the protective containers/wraps provided.

- If the equipment remains unused for several weeks, it is advisable to disconnect any power sources.

- Store within the environmental temperature limits of −25°C to +70°C.

8.2.3 In transportation

Correctly pack the equipment in the supplied transit case for transportation. Do not allow the equipment to slide around inside transport vehicles or containers.

8.2.4 General

Carry out regular functional testing of the system. Detect and report damage, malfunctions and poor performance to a Carlson-approved service centre.

It is advised to arrange an annual service and calibration. Contact Carlson for details.

9 Mechanical drawings

9.1 Merlin LT positioned at 90° vertical angle.

ISOMETRIC VIEW (1:5)
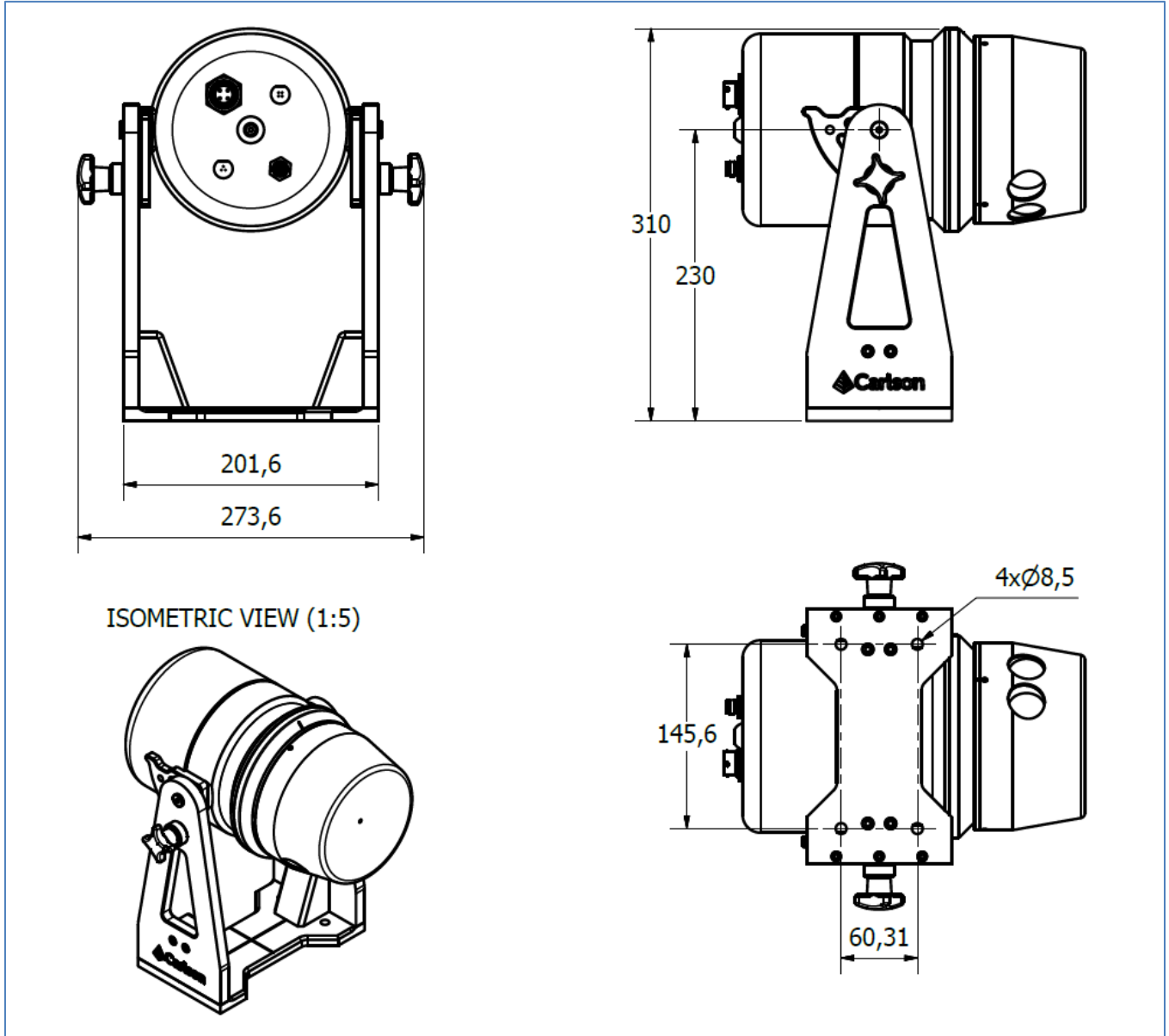
All dimensions in millimetres.

9.2 Merlin LT positioned at 0°vertical angle

115

230 (PIVOT POINT)

201,6

ISOMETRIC VIEW (1:5)

392,7

250

273,6

All dimensions in millimetres.

10 Laser safety

Merlin LT is supplied with one embedded laser module. See below for eye safety classification and recommendations.

DO NOT STARE DIRECTLY INTO THE BEAM

In accordance with BS EN 60825-1 : 2007 and US standards 21CFR 1040.10 and 1040.11, except for deviations pursuant to Laser Notice no. 50, dated June 24, 2007, the Merl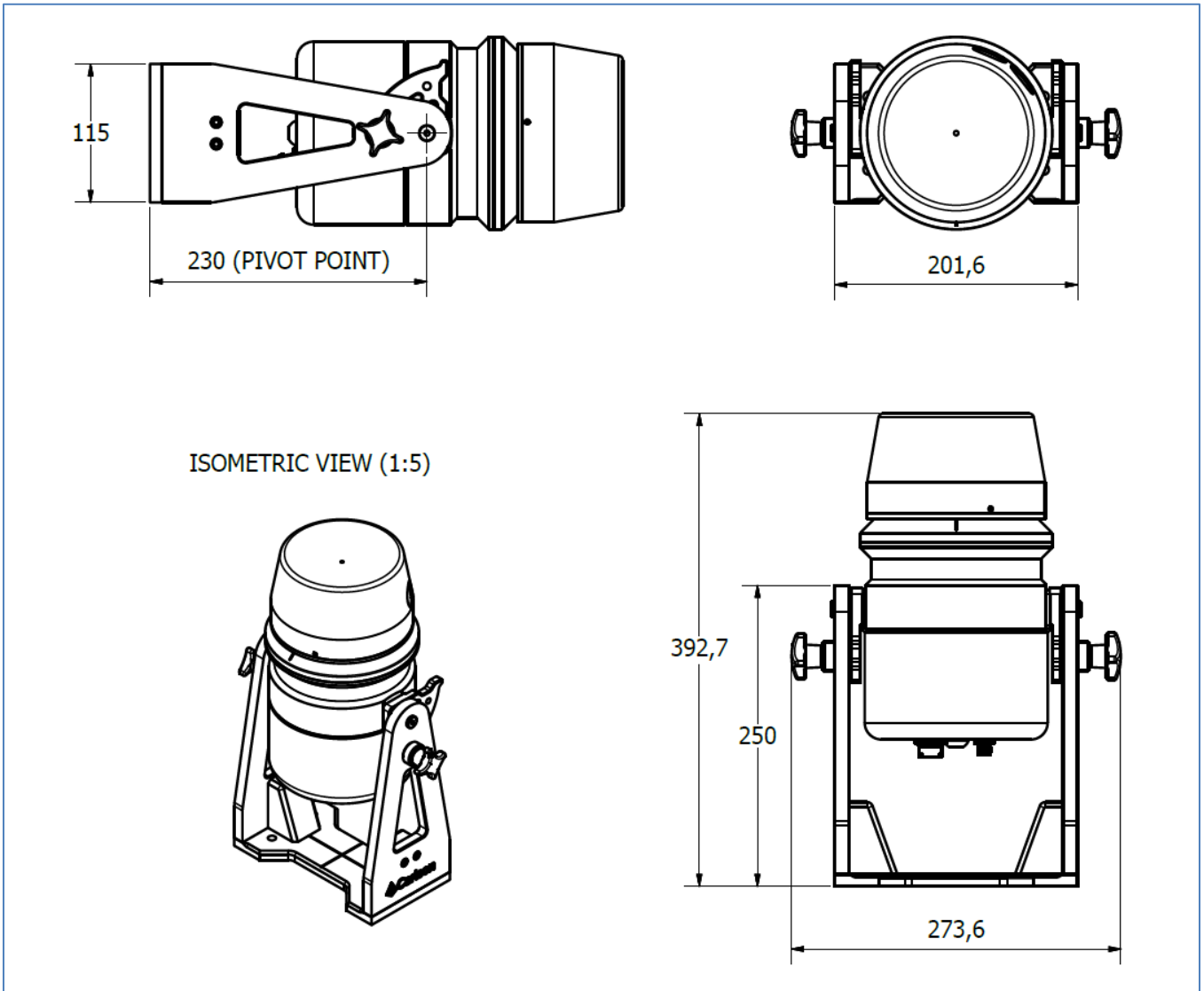in LT system is classified as a Class 1 invisible laser product. Safety eyewear is not required for Merlin LT. Do not stare into the beam or shine it into the eyes of others. It is safe to view a diffuse-reflected beam. Do not dismantle the unit in any way; doing so may expose laser radiation in excess of Class 1 limits.

10.1 Merlin LT laser module

The Merlin LT product is classified as a Class 1 laser product with reference to the international standard BS EN 60825-1 : 2007 Safety of Laser Products. As a Class 1 product, such devices require no engineering controls beyond requiring the use of tools to open the housing. No laser labelling is required to be located upon the external structure of these devices. However, the following label is located upon the external body of the product. It is clearly visible and readable to the user whether the device is in operation or not.

CLASS 1 LASER PRODUCT

WARNINGS:

- Invisible laser radiation. Do not stare into the radiated emitted beam.

- Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposures.

CAUTION - CLASS 3B INVISIBLE LASER RADIATION WHEN OPEN. AVOID EXPOSURE TO BEAM

WARNING: Opening the protective housing may result in exposure to Class 3B radiation.

This caution label is positioned inside the outer housing on the cover of the laser module emitter mount. It is

therefore only visible by qualified maintenance engineers prior to, and after, access to the laser emitter.

Only qualified and trained persons should be assigned to operate the Merlin product portfolio.

When not in use, the device should be stored in a location where unauthorised personnel cannot gain access.

CAUTION – LASER LIGHT IS BRIGHT AND BLINDING – DO NOT SHINE AT AIRCRAFT OR VEHICLES AT ANY DISTANCE

11 Compass safe distance

Compass safe distance testing determines the distances above which equipment will not cause an unacceptable deviation from a vessel's standard and steering compasses. The actual deviation varies with the strength of the earth's magnetic field around the world, but it is of the order 0.1° for the standard compass and 0.3° for the steering compass in equatorial regions, and rises to between 1° and 3° respectively in high altitudes.

Each assembly of the Merlin system was tested in the position and attitude relative to a test compass or magnetometer at which any error produced was a maximum, provided each element could be fitted in this way.

The compass safe distance of each considered assembly was defined as the distance between the nearest point of the unit and the centre of the compass or magnetometer at which the assembly would not produce a deviation in the standard compass of more than 5.4°/H, where H is the horizontal component of the magnetic flux density in µT (microtesla) at the place of testing.

For the steering compass, the standby steering compass and the emergency compass, the permitted deviation was 18°/H, H being defined as above.

Each Merlin assembly was tested:

- in the magnetic condition in which it is received with the assembly unpowered

- after normalising with the assembly unpowered

- in the powered condition, when the test assembly unit was capable of being energised electrically.

The Merlin unit has a standard compass safe distance of 80mm.

The Merlin unit has a steering compass safe distance of 60mm.

This is the worst case when the unit is powered.

12 Merlin LT Specifications

Laser module	
Laser classification (BS EN 60825-1 : 2007 and US standards 21CFR 1040.10 and 1040.11, except for deviations pursuant to Laser Notice no. 50, dated June 24, 2007)	Class 1
Type	InGaAs laser diode
Wavelength (typ)	905 nm
Accuracy*	±1 cm
Maximum energy per pulse	0.461 µJ
Beam divergence	2.25 x 1.5 mrads
Maximum range to a passive target**	250 m
Minimum range	0.5 m
Lens aperture size and location	28 mm (at front of model)
Scanner field of view	360°
Scanner angle of resolution	Up to 0.01*
Scan rate	Up to 20 Hz
Beam footprint at 50 m	141 mm x 103 mm
Pulse measurement rate (points per second)	36,000
Physical data	
Power input	12 V dc
Weight - Merlin LT with A-frame and base plate	8.0 kg
Weight - system in transit case	14.3 kg
Dimensions – Merlin (L x W x H) ***	28.0 cm x 27.4 cm x 31.0 cm
Dimensions – system in transit case (L x W x H)	55 cm x 35 cm x 22 cm
Environmental	
Water and dust resistant****	IP66 (marine grade)
Operating temperature	−10° C to +50° C
Storage temperature	−25° C to +70° C

Measuring accuracy recorded at 50 m against Kodak white card (90% reflectivity). Accuracy is defined as the degree of conformity of the measured sample mean range to its actual (true) value, measured with reference to a total station under Carlson test conditions.
*** Maximum measuring ranges are recorded to Kodak white card (90% reflectivity).*
**** When positioned at a vertical angle of 90°.*
***** Environmental compatibility requirements of EN 60529:1992+A1:2002*

13 Product information

Trademarks

CARLSON and the symbol used in the CARLSON logo are registered trademarks of Carlson in the United Kingdom and other countries. 'Breaking new ground' and names and designations of other Carlson products and technologies are trademarks of Carlson or its subsidiaries.

All other brand names and product names used in this document are trade names, trademarks, or registered trademarks of their respective owners.

Changes to Carlson products

Carlson reserves the right to improve, change or modify its products and documentation without incurring any obligation to make changes to equipment previously sold or distributed.

Carlson has made considerable efforts to ensure the content of this document is correct at the date of publication but makes no warranties or representations regarding the contact. Carlson excludes liability, howsoever arising, for any inaccuracies in the document.

Warranty

Unless otherwise specified, Carlson EMEA B.V. warrants the supplied equipment for a period of twelve months from the date of delivery. This warranty is given subject to the following conditions:

- Carlson EMEA B.V. shall be under no liability in respect of any defects in the equipment arising from any drawing, design or specification supplied or modification requested by the customer.

- Carlson EMEA B.V. shall be under no liability in respect of defects arising from, willful damage, negligence, abnormal working conditions, failure to follow Carlson's EMEA B.V. instructions (whether oral or in writing), misuse or alteration or repair of the equipment without Carlson's EMEA B.V. approval.

- Software is not covered by this warranty.

- Claims in respect of defective equipment must be intimated by notice in writing to Carlson EMEA B.V. and the equipment must be retained by the customer pending written instructions from Carlson EMEA B.V.

- Following authorised return of the equipment, which must be made by the customer on freight prepaid basis, Carlson EMEA B.V. will examine the equipment and, if the claim is justified in Carlson EMEA B.V.'s opinion, will repair the defective equipment or will make replacement without charge. Carlson EMEA B.V. will have no further liability to the customer.

Safety

The Merlin LT vessel-based lidar system is a robust, ruggedised, vessel-mountable, time-tagged laser scanning system whose applications include the 3D mapping of canals, inland waterways, shoreline, headlands, ports and harbours. It is essential that the unit and all accessories are operated in accordance with the instructions in this operation manual and it is the responsibility of the user to ensure that, in the event of a failure on any part of the Carlson system, the laser system remains safe.

In the case of laser systems with powers or speeds capable of causing injury, it is essential that appropriate safety protection measures are included in the machine usage. Further guidance can be found in the European BS EN ISO 12100 : 2010 *Safety of machinery – General principles of design – Risk assessment and risk reduction*.

This symbol is used in this manual wherever important safety information is present. Before proceeding with any electrical connection or operation of the laser system, refer to the general safety information listed throughout this manual.

Information to the equipment supplier/ installer

It is the equipment supplier's responsibility to ensure that the user is made aware of any hazards involved in any operations involving the Merlin LT vessel-based lidar system, including those mentioned in Carlson product literature.

Declaration of conformity

The Merlin LT system meets or exceeds the requirements of the following British and European Standards:

BS EN ISO 12100 : 2010 –
Safety of machinery – General principles for design

EN 60945 : 2002 –
Maritime navigation and radio communication equipment and systems – General requirements – Methods of testing and required test results

> 9 – Electromagnetic emission.

> 10 – Immunity to electromagnetic environment.

> 11 – Special purpose tests.

BS EN 60825-1 : 2007 –
Safety of laser products – Part 1: Equipment classification and requirements

BS EN 62471 : 2008 –
Photobiological safety of lamps and lamp systems

The Merlin LT system therefore complies with the following European Directives:

2006/42/EC – Machinery

2004/108/EC – Electromagnetic compatibility (EMC) of electrical equipment

2006/95/EC – Low voltage directive (LVD) relating to electrical equipment designed for use within certain voltage limits (codified version)

It is declared that the equipment named has been designed to comply with the relevant sections of the referenced specifications and is in accordance with the requirements of the Directives.

EC declaration of conformity

Carlson declares that the Merlin LT vessel-based lidar system and associated accessories complies with the applicable standards and regulations.

$C\epsilon$

Contact Carlson or visit www.carlsonsw.com for the full EC declaration of conformity.

Laser safety

 DO NOT STARE DIRECTLY INTO THE BEAM

In accordance with BS EN 60825-1: 2007 and US standards 21CFR 1040.10 and 1040.11, except for deviations pursuant to Laser Notice no. 50, dated June 24, 2007, the Merlin LT system is classified as a Class 1 invisible laser product. Safety eyewear is not required for Merlin LT. Do not stare into the beam or shine it into the eyes of others. It is safe to view a diffuse-reflected beam. Do not dismantle the unit in any way; doing so may expose laser radiation in excess of Class 1 limits.

CAUTION – LASER LIGHT IS BRIGHT AND BLINDING – DO NOT SHINE AT AIRCRAFT OR VEHICLES AT ANY DISTANCE

FCC (USA only)

Information to the user (47CFR section 15.19)

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and

2. This device must accept any interference received, including interference that may cause undesired operation.

Information to the user (47CFR section 15.21)

The user is cautioned that any changes or modifications not expressly approved by Carlson or authorised representative could void the user's authority to operate the equipment.

Information to the user (47CFR section 15.105)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WEEE directive

The use of this symbol on Carlson products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling. Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, please contact your local waste disposal service or Carlson representative.

Battery safety

- Do not attempt to recharge batteries.

- Please dispose of waste batteries in accordance with your local environmental and safety laws.

- Replace the batteries only with the specified type.

- Ensure that all batteries are inserted with the correct polarity.

- Do not store batteries in direct sunlight.

- Do not heat or dispose of batteries in a fire.

- Do not short-circuit or force discharge the batteries.

- Do not introduce a metal connection between the batteries in the nose cone and the external metal housing.

- Do not disassemble, pierce, deform or apply excessive pressure to the batteries.

- Do not swallow the batteries.

- Keep the batteries out of the reach of children.

- Do not get batteries wet.

- If a battery is damaged, exercise caution when handling it.

Battery disposal

The use of this symbol on the batteries, packaging or accompanying documents indicates that used batteries should not be mixed with general household waste. Please dispose of the used batteries at a designated collection point. This will prevent potential negative effects on the environment and human health which could otherwise arise from inappropriate waste handling. Please contact your local authority or waste disposal service concerning the separate collection and disposal of batteries. All lithium and rechargeable batteries must be fully discharged or protected from short circuiting prior to disposal.